016.53
P578
Illinois U Library

PHYSICS ABSTRACTS

SECTION A

of

SCIENCE ABSTRACTS

SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

Edited and Issued Monthly by

THE INSTITUTION OF ELECTRICAL ENGINEERS

In Association with

THE PHYSICAL SOCIETY

THE INSTITUTE OF PHYSICS

THE AMERICAN PHYSICAL SOCIETY

THE AMERICAN
INSTITUTE OF ELECTRICAL ENGINEERS

Co-operating member of the I.C.S.U. Abstracting Board (International Council of Scientific Unions)

ABSTRACTS 5813–6673

VOLUME 58 **AUGUST 1955** NUMBER 692

Some *NEW* VACUUM 'METALLIZING' DEVELOPMENTS BY EDWARDS . . .

REACTIVE SPUTTERING UNIT

. . . OF INTEREST TO OPTICAL AND ELECTRONIC PHYSICISTS . . .

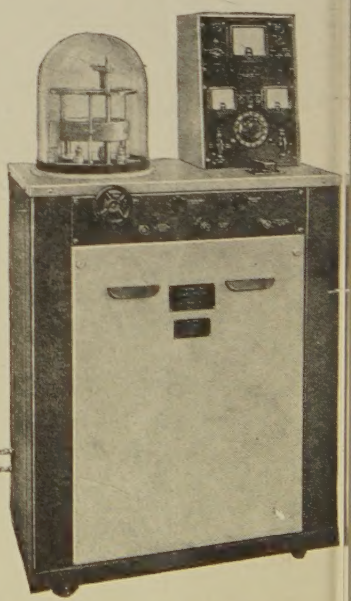
MODULATED BEAM-PHOTOMETER

INDIVIDUAL H.F. CRYSTAL COATING PLANT

REACTIVE SPUTTERING PLANT . . . a unit incorporating developments of sputtering technique including the deposition of transparent conductive metal oxide films in a controlled oxygen atmosphere.

A device for all applications where the deposition of single and multi-layer coatings must be critically controlled to achieve uniform and specified thickness.

A new single crystal unit is now available for individual frequency calibration of H.F. Crystals during deposition.



EDWARDS HIGH VACUUM LTD. . . . *FOR BETTER VACUUM SERVICE*

MANOR ROYAL · CRAWLEY · SUSSEX
CRAWLEY 1500 (10 lines) EDCOHIVAC CRAWLEY

BRANCHES: GLASGOW & TORONTO
AGENTS THROUGHOUT THE WORLD

Principal Contents

AUGUST 1955

		PAGE
51	MATHEMATICS	749
52	ASTRONOMY. ASTROPHYSICS. GEODESY	749
53	PHYSICS	753
530.1	Fundamentals	753
531	General mechanics. Mechanics of solids	—
531.7	Mechanical measurements	760
532	Mechanics of fluids	761
532.6	Capillarity	763
532.7	Molecular theory of liquids	763
533	Mechanics of gases	765
533.7	Molecular theory of gases	765
534	Vibrations. Acoustics	766
535	Optics. Radiation. Spectra	769
536	Heat	781
536.7/.8	Thermodynamics	784
537	Electricity	785
537.2	Electrostatics. Dielectrics	785
537.3	Electric conduction. Currents	788
537.52	Electric discharges	794
537.531	X-rays	798
537.533/.534	Cathode rays. Positive rays	799
537.54	Discharge tubes. Counters	804
537.56/.58	Ionization. Thermionics	805
537.591	Cosmic rays	806
538	Magnetism	809
538.3/.5	Electromagnetism. Electrodynamics	813
538.56	Electromagnetic waves and oscillators	813
539.1	Molecular and atomic structure	816
539.11	Theory of solid state	816
539.13	Molecules	818
539.15	Atoms. Nucleus. Isotopes	822
539.16	Radioactivity. α-, β- and γ-rays	825
539.17	Nuclear reactions	829
539.18	Atom and molecular beams. Mesons. Neutrons	833
539.2	Structure of solids	840
539.3/.8	Elasticity. Strength. Rheology	842
541	PHYSICAL CHEMISTRY	844
541.11/.12	Phase equilibrium. Chemical reactions	844
541.13	Electrochemistry	845
541.14/.15	Photochemistry. Radiation chemistry	846
541.18	Dispersions. Colloids. Adsorption	847
541.2/.6	Chemical structure	848
543/545	Chemical analysis	848
548	CRYSTALLOGRAPHY	850
548.7	Atomic and X-ray crystallography	850
55	GEOPHYSICS	854
551.5	Atmosphere. Meteorology	856
57/59	BIOLOGY	859
61	Medical science. Human physiology	859
62/69	TECHNIQUE. MATERIALS	860
77	Photography	860

RELATED SUBJECTS CONTAINED IN SECTION B (ELECTRICAL ENGINEERING ABSTRACTS)

Electrical and magnetic measurements and instruments
Electronic relays and counters
Automatic control mechanisms
Applied electrochemistry
Lines and networks
Waveguides
Photocells
Thermionic tubes
Cathode-ray tubes
X-ray tubes
Oscillators. Pulse circuits
Amplifiers
Electroacoustic apparatus
Radiocommunication
Mechanical engineering
Illumination

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 56 (1953) and the Supplements published with the Indexes to Volumes 56 (1953) and 57 (1954). Reprints of the List of Journals (1953) and the Supplements (1953 and 1954) can be obtained from The Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. 0d. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Ann. Math.	*Annals of Mathematics.* [Abstracted by *Mathematical Reviews*].
J. Polymer Sci.	*Journal of Polymer Science.* [Abstracted by The British Scientific Instrument Research Association].
Proc. Indian Assoc. Cultiv. Sci.	*Proceedings of the Indian Association for the Cultivation of Science.* Contained in *Indian Journal of Physics.*

New Journal

Publ. sci. Univ. d'Alger	*Publications Scientifiques de l'Université d'Alger. Série A: Sciences Mathématiques. Série B: Sciences Physique.* Secrétaire des Publications, Faculté des Sciences, 2 rue Michelet, Algiers, Algeria. Série A, Volume 1, Number 1 dated *June*, 1954. Annual subscription: Série A, 2500 Fr; Série B, 2500 Fr; Séries A and B, 4000 Fr.

Errata

Abstr. 5288 (1955) line 2: *for* M. F. CANAC *read* F. CANAC.

Abstr. 5348 (1955) line 2: *for* M. G. NOMARSKI *read* G. NOMARSKI.

Abstr. 5583 (1955) line 4: *add at end of line* energy to the diffuseness of the surface.

Abstr. 5686 (1955) line 8: *for* Gittl *read* GITTL.

Corrections to Articles

Corrections have been published, as shown below, to the articles whose abstract numbers are given. Unless otherwise stated, the volume and page given refer to the journal named in the abstract, i.e. the journal in which the original article was published.

Abstr. 10247 (1954): **12,** *No.* 6, 293 (1955).

Abstr. 2654 (1955): **26,** *No.* 6, 783 (*June*, 1955)

Abstr. 3940 (1955): **23,** *No.* 6, 1178 (*June*, 1955).

MATHEMATICS 51

518.2

5813. Notes on tables of trigonometrical functions. G. KORFF. *Optik*, **12**, *No.* 3, 136–49 (1955) In German.

It is suggested that there would be a considerable reduction in the space taken up if trigonometrical tables were set out differently from the present manner. The division of the right angle into 100 degrees is advocated. The large differences of sin x in the region of small x make interpolation inaccurate and by tabulating $(\sin x)/x$, a function which changes more slowly, fewer entries would be required in the table. Similar considerations apply to $(\tan x)/x$ for values of x up to about 45°. Above this value $x/(\tan x)$ is considered a more suitable function to tabulate. The author suggests a complete re-investigation of methods of tabulating all functions, having regard to present-day mechanical methods of computation. N. CORCORAN

518.5

5814. A proposed modification to the C.S.I.R.O. Mark I computer. B. E. SWIRE. *Austral. J. Phys.*, **8**, *No.* 1, 184–6 (*March*, 1955).

518.5 : 621.3.011

5815. Detailed example of interconnecting piecewise solutions. G. KRON. *J. Franklin Inst.*, **259**, *No.* 4, 307–33 (*March*, 1955).

Detailed description is given of all the steps involved in inverting on a small digital computer (such as the CPC) a special type of 63×63 matrix. This matrix may represent the linear equivalent circuit of the field equations of Maxwell, or the diffusion equation of a nuclear reactor, etc. Or it may represent the equivalent circuit of a non-linear partial differential equation for one particular situation. These networks have, however, the special property that each subdivision is separately grounded. In the example given, the physical system is torn apart into four parts, each part is solved independently of the others, then the solutions are interconnected. The inverse matrix is given also in a factorized form, more suitable than an actual inverse for many purposes. A simple numerical example is also worked out step-by-step. A.

518.5 : 621.374.32 : 621.318.3

5816. Multiple coincidence magnetic storage systems. R. C. MINNICK AND R. L. ASHENHURST. *J. appl. Phys.*, **26**, *No.* 5, 575–9 (*May*, 1955).

In existing magnetic matrix storage systems a given location is selected by applying to two intersecting wires a current equivalent to one-half of the selecting field. This situation is generalized so that any core is selected by energizing p wires each with a current equivalent to $1/p$ of the selecting field. The advantages gained are in the correspondingly smaller fields applied to the non-selected cores, or alternatively, in the faster switching times obtainable by applying a total field greater than the coercive force to the selected core. To obtain the increased selection ratio $p-2$, additional sets of wires must be introduced into the matrix. Methods for accomplishing this are developed with the aid of a system analogous to plane analytic geometry for a finite set of points. Utilizing the increased selection ratio new fabrication techniques may be employed. Specifically, a storage matrix is illustrated in which the cores are toroids etched from a continuous sheet of magnetic material. A.

519.2

5817. Change of variables in distributions and their Fourier transforms. R. SCARFIELLO. *Nuovo Cimento*, **12**, *No.* 4, 471–82 (*Oct.*, 1954) In French.

The effect of a change of variable is studied, when the distribution is considered as a current. The operations are carried out in a Euclidean space. The Fourier transform of a current is defined, and used to obtain some properties of the transform of a distribution. For the Theory of Distributions reference may be made to the book, of this title, by L. Schwartz (Paris, 1950–51). L. S. GODDARD

ASTRONOMY . ASTROPHYSICS . GEODESY 52

523.11 : 530.12

5818. Relativistic cosmology. I. A. RAYCHAUDHURI. *Phys. Rev.*, **98**, *No.* 4, 1123–6 (*May* 15, 1955).

Presents some general relations obtaining in relativistic cosmology. It appears from these that a simple changeover to anistropy without the introduction of spin does not solve any of the outstanding difficulties of isotropic cosmological models. A.

523.161 : 523.164

5819. Association of gas and dust from 21-cm hydrogen radio observations. A. E. LILLEY. *Astrophys. J.*, **121**, *No.* 3, 559–68 (*May*, 1955).

Dust clouds in Taurus, Orion and Perseus have been observed by means of the 21 cm hyperfine emission line of interstellar hydrogen. Dust clouds at intermediate galactic latitudes are strong 21 cm emitters when compared to adjacent, less dusty regions. Coincident values of gas and dust optical depths show a good correlation for these clouds. Assuming similar distributions in distance for the gas and dust, a determination follows for the average interstellar spatial density ratio of gas to dust. The individual observed values of the gas-to-dust density ratio range from 35 to 250 and have a mean value of 100. A minimum mass of 21 000 $M_\odot$ is obtained for the H I content of the dust complex. The results indicate the dust content to be approximately 200 $M_\odot$, 1% of the gas content. The gas and dust data, when compared with stellar-distribution data, suggest similar distributions of gas, dust and stars in the anti-centre. A.

523.161 : 523.164

5820. Some features of interstellar hydrogen in the section of the galactic center. D. S. HEESCHEN. *Astrophys. J.*, **121**, *No.* 3, 569–84 (*May*, 1955).

Several results of observations of the 21 cm line in the section of the galactic centre are discussed. A general positive correlation between the amount of obscuration and the number of neutral hydrogen atoms is found. The root-mean-square random radial cloud velocity at high latitudes is found to be 4·4 km/sec. The profiles at low galactic latitudes show a complex nature, with double peaks and asymmetries, which in this direction cannot be due to galactic rotation. Two alternative hypotheses are suggested as an explanation. Some indications of systematic deviations from purely circular galactic rotation are found. A.

523.161 : 523.164

5821. Preliminary 21-cm meridian plane surveys. H. L. HELFER AND H. E. TATEL. *Astrophys. J.*, **121**, *No.* 3, 585–603 (*May*, 1955).

Surveys of the 21 cm hydrogen emission radiation in the meridional plane $l = 50°$ and $l = 90°$ are reported. Both regions are characterized by hydrogen apparently extending to great distances from the galactic plane and by hydrogen possessing velocities not in accord with the galactic model proposed by Oort, which is based upon the assumption of regular circular galactic motions. An investigation of the peculiar velocity distribution of the hydrogen gas results in a velocity dispersion of about 3·5 km/sec which is considerably less than that found by other investigators (average velocity about 3·5 km/sec). A.

523.162.2

5822. Freundlich red-shift formula. M. A. MELVIN. *Phys. Rev.*, **98**, *No.* 4, 884–7 (*May* 15, 1955).

Freundlich has attempted to explain various anomalous observations by suggesting that the red shift be reinterpreted as an effect proportional to radiation density and length along the path of a photon. For a star of radius R the contribution of the outside radiation field exceeds that within the atmosphere (thickness l_0) by a factor of the order of $R/l_0 = 1\,000$ for average stars; this makes Freundlich's original formula untenable. The question is here examined whether the objections to Freundlich's conception can be removed if one reduces his constant of proportionality by 10^{-3}. To give the conception a full trial the calculations are made realistically, taking into account the extension of the star, and the deviations from Lambert's law of emission which result from the radiative transfer conditions in the photosphere. The resultant formula for the radiation shift gives an approximate fit with solar observations out to near the limb without retaining, as Freundlich does, an additional relativity shift equal to one-fifth of the expected value. However, the rise of the observed shift at the limb to the gravitational value (and even higher) is unaccounted for. The serious objections to Freundlich's interpretation from other astronomical evidence still stand, though the order of magnitude of the discrepancies is in some instances considerably reduced. A.

523.164

5823. Sharpening of observational data in two dimensions. E. J. BURR. *Austral. J. Phys.*, **8**, *No.* 1, 30–53 (*March*, 1955).

Distributions in two dimensions as measured are always blurred or smoothed by limitations in the observing technique. Recovery of the true distribution involves the solution of an integral equation of the form $g(x', y') = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} h(x, y) f(x'-x, y'-y)dx\,dy$, where the functions g, h are known from observation. In this paper the uniqueness and stability of the solution are discussed, and the validity and usefulness of several methods of solution are examined. A new technique for the application of polynomial solutions is presented. It is suggested that in some cases the use of Fourier transforms or Fourier–Bessel transforms may be practicable, and tables of selected transforms are supplied. Finally, conditions for convergence of certain sequences of approximate solutions are given. The effect of random errors in the observational data is taken into account wherever possible. A.

523.164

5824. Correcting for Gaussian aerial smoothing. R. N. BRACEWELL. *Austral. J. Phys.*, **8**, *No.* 1, 54–60 (*March*, 1955).

Let a two-dimensional survey with a Gaussian aerial beam establish values at intervals of $\sqrt{2}$ standard deviations. Then the correction for aerial smoothing is simply calculated as the difference between the value to be corrected and the mean of the neighbouring four values. A.

523.164

5825. A radio survey of the great loop in Cygnus. D. WALSH AND R. H. BROWN. Letter in *Nature* [*London*] **175**, 808–9 (*May* 7, 1955).

With a 218 ft fixed paraboloid on 92·5 Mc/s, a source close to the great Cygnus loop, and of comparable angular diameter, has been found, and it is tentatively identified with the loop. Its intensity is $200 \pm 100 \times 10^{-24}$ watts. $m^{-2}.(c/s)^{-1}$. M. W. OVENDEN

523.4 : 539.89

5826. The gravitational compression of an elastic sphere. A. KEANE. *Austral. J. Phys.*, **8**, *No.* 1, 167–75 (*March*, 1955).

On considering a sphere in hydrostatic gravitational equilibrium, composed of a homogeneous elastic material for which the variation of incompressibility × with pressure p is given by $dx/dp = n$, a constant, it is found that there is an upper bound to the radius R of the sphere provided $n \leqslant 2$, and that for all values of n there is a lower bound to the value of I/MR^2, where I is the moment of inertia about a diameter and M is the mass of the sphere. For a sphere composed of material for which dx/dp is a decreasing function of pressure and $dx/dp \to 5/3$ as $p \to \infty$, it emerges that $0{\cdot}40 > I/MR^2 > 0{\cdot}23$ and that the maximum radius is of the order of 10^4 km. A.

523.42

5827. Indication of a magnetic field of the planet Venus. J. HOUTGAST. Letter in *Nature* [*London*] **175**, 678–9 (*April* 16, 1955).

Statistical plots of international daily magnetic character figure (C) for days, −23 to +17 with

respect to each of 44 inferior conjunction dates of the planet in the available period, Jan. 1884 to Dec. 1953, using the method of superposition, show that the value of C is markedly reduced during the interval, 7 days before to 1 day after the conjunction. This decrease is particularly marked when the material is restricted to dates for which the sunspot number, R, is <50, i.e. when the effect of the corpuscular stream on geomagnetic activity will be most pronounced. These results suggest a deflection of the solar stream by a magnetic field surrounding Venus. Assuming a dipole field, this will have a strength $\sim 5\times$ that of the earth's, and a similar N–S orientation. D. R. BARBER

523.5

5828. Radio echo observations of meteors in the southern hemisphere. A. A. WEISS. *Austral. J. Phys.*, **8**, *No.* 1, 148–66 (*March*, 1955).

The results of a radio survey of meteor activity at Adelaide are presented. The radiants and activities of six major meteor showers (Geminids, day-time Arietids, ζ-Perseids, δ-Aquarids, Corona Australids, Orionids) have been measured by methods which are described, and the mass distributions in three of these showers are discussed. Seasonal and diurnal variations in the background activity of sporadic meteors are examined in relation to the radiation patterns of the aerial systems. Height distributions for meteors of three showers (Geminids, day-time Arietids, ζ-Perseids) are given. Diurnal variations in the height distribution of sporadic meteors do not conform to those expected from the motion of the apex of the earth's way. A.

523.59

5829. A comet model. III. The zodiacal light. F. L. WHIPPLE. *Astrophys. J.*, **121**, *No.* 3, 750–70 (*May*, 1955).

For Pt II, see Abstr. 6685 (1951). The Poynting–Robertson effect is shown to require about 1 ton/sec of small particles to maintain the zodiacal cloud, irrespective of particle shape, density, or dimension within the range of 10^{-4}–$1{\cdot}0$ cm. The zodiacal cloud is assumed to be of the nature deduced by van de Hulst and Allen from their studies of the Fraunhofer corona and the zodiacal light. The probable cometary contribution to the zodiacal cloud is here considered on the basis of the icy-comet model. Some 30 tons/sec of meteoritic material contributed continuously in typical comet orbits are mostly lost by the action of the following physical forces or processes as the particles spiral inward toward the sun by the Poynting–Robertson effect: (*a*) interstellar wind, (*b*) Jupiter's random perturbations (*c*) the Jupiter perturbational barrier, and (*d*) collisional destruction. Of these, *b* and *d* are found to be the most important. The final calculated contribution is about the required amount. Collisions among the particles appear to be largely responsible for the cutoff in zodiacal particle size above about $0{\cdot}03$ cm, as found by van de Hulst. Corpuscular radiation from the sun will simulate the Poynting–Robertson effect but will simultaneously tend to destroy the particles. No allowance for this effect is included in the calculations because of uncertainties in the numerical quantities involved. Corpuscular radiation, however, if sufficiently powerful, may exceed the Poynting–Robertson effect in importance and may also demand a larger source of material for the zodiacal cloud. If so, the corpuscular radiation will also increase the critical cutoff dimension. A.

523.72

5830. Luminance of the sun. R. V. KARANDIKAR. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 483–8 (*June*, 1955).

Using a photoelectric telephotometer and a calibration source, drift curves of the luminance of the sun along a diameter were obtained for different zenith distances of the sun on clear days. After extrapolation to zero air mass, the luminance $B(0,0)$ at the centre of the sun's disk observed outside the earth's atmosphere was obtained as $243\,000 \pm 5\,000$ candles/cm^2. The data obtained for the radial distribution of luminance being comparatively less accurate, the standard limb darkening data of Abbot and others were used to give the average luminance $\bar{B} = 193\,000 \pm 4\,000$ candles/cm^2 and the extraterrestrial total solar illumination $\bar{E}_0 = 12\,200 \pm 300$ lumens/ft^2 for the mean solar distance. Previous determinations of $\bar{E}_0$ found in the literature are reviewed and compared with these results. A.

523.72 : 550.385

5831. Photoelectric investigations of solar corpuscular radiation. II. M. J. SMYTH. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 5, 503–13 (1954).

Photoelectric measurements of the solar K-line in 1951 and 1953, with improved equipment, confirm the conclusion of the previous part [Abstr. 1461 (1955)] that absorption in the violet wing, corresponding to particles approaching with speeds between 750–1 150 km/sec, does not exceed $\frac{1}{2}\%$ at any time following moderately intense flares. There is also little evidence of absorption of this magnitude associated with sequences of recurrent geomagnetic storms. A.

523.746·5

5832. The asymmetry of the sunspot curve. W. GLEISSBERG. *Rev. Fac. Sci. Univ. Istanbul C*, **19**, *No.* 3, 219–27 (*July*, 1954) In German.

If the ratio $(U-T)/(U+T)$ denotes the observed asymmetry A_1 of the 11 yr sunspot cycle where U is the interval in years from maximum to the next minimum, and T is the interval from min. to max., it is shown that, for all cycles since 1615, there has been on the average, a progressive increase of A_1. Further, this increase may be eliminated by using the relation, $A_1' = A_1 - 0{\cdot}0122\,(n+6)$, where n is the Zürich serial number of the relevant 11 yr cycle; and the secularly-smoothed values of A_1' reveal an 80 yr solar cycle. D. R. BARBER

523.752

5833. Temperature and turbulence in the chromosphere. R. O. REDMAN AND Z. SUEMOTO. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 5, 524–39 (1954).

523.752

5834. The rotational temperature of the lower solar chromosphere. J. M. PARKER. *Astrophys. J.*, **121**, *No.* 3, 731–8 (*May*, 1955).

From spectra of the lower solar chromosphere taken outside eclipse, rotational temperatures have been derived from the (0, 0) and (0, 1) bands of C_2.

Using the intensities of 83 lines, a rotational temperature of 4 610°K was found, with a probable error of approximately 400°K. A.

533.77

5835. Study of the continuous background of the solar spectrum. I. Introduction. R. PEYTURAUX. *Ann. Astrophys.*, **18**, *No.* 1, 25 (1955) In French.

Essentially the work comprises the measurement of the solar centre to limb darkening and the absolute measure of the solar energy at the centre of the disk using spectra from 3 000 to 23 000 Å. E. G. MARTIN

523.77

5836. Study of the continuous background of the solar spectrum. II. Principal optical instruments built for the study of the continuous backgr[illegible] circu[illegible]f the solar spectrum. A. BAILLET AND R. [illegible]AUX. *Ann. Astrophys.*, **18**, *No.* 1, 26–31 (19[illegible]nch.

Describes the instruments u[illegible] 523[illegible]dy the above work, including the polar siderosta[illegible]mployed to project the image of the sun, the details of the monochromator and its resolution, dispersion, etc., the means of photographic registration and the optical reversing mirror apparatus. Photographs and plans illustrate the descriptions. E. G. MARTIN

523.77

5837. Study of the continuous background of the solar spectrum. III. A tuned generator. F. BOSSON AND R. PEYTURAUX. *Ann. Astrophys.*, **18**, *No.* 1, 32–3 (1955) In French.

Contains the circuit diagram and description of the electronic control attached to the drive of the polar siderostat. E. G. MARTIN

523.77

5838. Study of the continuous background of the solar spectrum. IV. The centre-limb darkening of the sun between 3 190 Å and 23 130 Å. R. PEYTURAUX. *Ann. Astrophys.*, **18**, *No.* 1, 34–41 (1955) In French.

Gives details of the type of detectors used and the exact wavelengths at which records were secured. The measures at different radii across the solar disk are tabulated and comparisons of the results with other workers are made graphically. Finally a determination of the Balmer discontinuity at 3 700 Å is made which compares favourably with the results of other investigators. The observations were made at the Observatory of Haute-Provence during 1952 and 1953. E. G. MARTIN

523.774

5839. Equivalent widths of atomic lines in sunspot spectra. K. D. ABHYANKAR AND A. S. RAMANATHAN. *Astrophys. J.*, **121**, *No.* 3, 739–49 (*May*, 1955).

Equivalent widths of 82 Cr I lines, 70 Fe I lines and 74 Ti I lines are measured in the spectra of four sunspots of average area 55 millionths of the visible hemisphere of the sun. Separate curves of growth for Cr I, Fe I and Ti I are constructed. Excitation temperatures of 4 030 ± 80°, 4 200 ± 150° and 3 800 ± 100° are obtained for Cr I, Fe I and Ti I, respectively. A.

523.775

5840. An identification of the coronal line λ5694. A. M. NAQVI AND S. P. TALWAR. Note in *Astrophys. J.*, **121**, *No.* 1, 287–9 (*Jan.*, 1955).

An attempt to identify the yellow coronal line λ5694 which is very variable in brightness. As the wavelengths of highly ionized atoms have not yet been observed in the laboratory, extrapolation has been employed with resulting considerable errors. Examples of extrapolated calculated wavelengths are given as demonstrating the fit with measures. The several suggested identifications for this line are discussed. E. G. MARTIN

523.841

5841. Field reversal in magnetic variable stars. P. A. SWEET. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 5, 549–57 (1954).

In connection with oscillation theories of magnetic variable stars the limitation in the variation of the observed magnetic field strength H_e imposed by Cowling's boundary condition is examined. Discussion is restricted to fields that remain symmetrical about a fixed axis during their variation. In spherical stars with a coefficient of limb darkening 0·45 it is found that, provided suitable gas motions can arise, reversal is possible only in the following cases: (i) dipole-type fields with distortions that are not symmetrical about the equatorial plane, when the inclination i of the magnetic axis to the line of sight exceeds 79°; (ii) symmetrical quadrupole-type fields with symmetrical distortions, when $50° < i < 69°$; (iii) quadrupole-type fields with unsymmetrical distortions, for all values of i; (iv) certain fields of higher complexity even when symmetrical, for all values of i. Statistical considerations indicate that it is improbable that dipole or symmetrical quadrupole-type fields can account for observations. The paper is not concerned with the dynamics of the gas motions. A.

523.877

5842. The influence of stellar radiation on the rate of accretion. L. MESTEL. *Monthly Not. Roy. Astron. Soc.*, **114**, *No.* 4, 437–59 (1954).

Bondi's discussion of spherically symmetric accretion is extended to take account of the heating of the cloud by ultraviolet radiation from the star. It is shown that if the accretion rate is to be high, the radius of the *H* II zone must not be more than about one thousand stellar radii. The absorbing power of a cloud is enormously increased by the high densities near the star, so that a cloud of moderately high density at infinity is able to keep the *H* II zone small enough for rapid accretion to take place. For a star of given type, there is a lower limit to the cloud density that will keep the *H* II zone small; when a star, accreting from a cloud of given density, reaches a critical mass, the *H* II zone increases rapidly to Strömgren's value, and accretion effectively ceases. The conditions under which the state of rapid accretion can be set up are investigated: it is shown, for example, that this state can be reached with the cloud density 10^3 particles/cm^3 and temperature 100 deg. K, provided the star entering the cloud is of mass less than $1 \cdot 75 \odot$. A.

523.877

5843. Radiative equilibrium of a line-absorbing atmosphere. I. J. I. F. KING. *Astrophys. J.*, **121**, *No.* 3, 711–19 (*May*, 1955).

The radiative-transfer theory for band-absorbing semi-infinite atmospheres possessing line structure is developed by extending the formalism of

Chandrasekhar to an integration over frequency space as well as over $\mu = \cos\theta$ space. The generalized Hopf–Bronstein relation which results is independent of the detailed line structure and is a function solely of the greyness parameter $\bar{\lambda}$, the square-root product of the arithmetic and harmonic means of the absorption coefficient. The effect of line structure on equilibrium configurations and limb darkening is obtained by using the Elsasser band model, which conveniently incorporates deviations from greyness in a single parameter, β. A.

523.877 : 537.56

Equilibrium of thermally ionized gas. *See Abstr.* 6249

525.722

5844. Statistical analysis of star scintillations as a means for investigating atmospheric disturbances. R. FÜRTH. *Physics of the ionosphere* [*Cambridge*] 140–9. See Abstr. 5763 (1955).

It is shown that significant features of the phenomenon of brightness fluctuations of star images can be revealed when records of such fluctuations are subjected to a statistical analysis on the basis of well-known principles of the theory of stochastic processes. The method used consisted in computing the so-called "after-effect function" for a statically stationary series of observations from the shape of which definite conclusions can frequently be drawn as to the character of the elementary processes which give rise to the fluctuation phenomenon. The method was applied to records of star scintillations obtained by Ellison and Seddon with telescope apertures between 36 and 3 in. It appears that the fluctuations are due to a more or less random sequence of "pulses" of a few hundredths of a second duration and average intervals depending on the size of the aperture. This can be satisfactorily interpreted as the result of the passage of "schlieren" patches over the telescope mirror, of about 30 to 40 cm width, moving with an average speed of about 15 m sec^{-1}. The nature and location of the disturbances which are responsible for the schlieren is discussed and the application of the same method to the statistical analysis of fluctuations of signals from radio stars is suggested. A.

525.73

5845. Daylight visibility of stars from a long shaft. A. G. SMITH. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 482–3 (*June*, 1955).

Photometric measurements indicate that the presence of a long shaft causes no real change in the contrast of a star against the daytime sky. Moreover, physiological data suggest that contrary to popular opinion such a shaft may actually have an adverse effect on the daylight visibility of stars. A.

PHYSICS 53

53.08

5846. Partially balanced incomplete block designs with two associate classes and two treatments per block. W. H. CLATWORTHY. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 4, 177–90 (*April*, 1955).

In physical science experimentation the experimental material may divide naturally into groups of two objects (treatments) each. Thus, the experimental arrangement will involve what is known in the design of experiments as an incomplete block design. In this paper an investigation is made of a special kind of incomplete block design known as the partially balanced incomplete block design with two associate classes. In these designs the various comparisons of pairs of objects involve two kinds of precision. An enumeration is made of all partially balanced incomplete block designs with two associate classes and two treatments per block where r, the number of times each treatment appears in the arrangement, is less than or equal to 10. Simple instructions are given for writing the experimental arrangements. These designs have a definite known method for analysis of the data. No attempt has been made to state which of the various designs are best, since it is felt that the best design must be determined for the particular investigation. A.

53.081.5

5847. Dimensions of a solid angle. O. REEB. *Optik*, **12**, *No.* 4, 196–9 (1955) In German.

Reasons are given for assigning to solid angles a dimension which is independent of the dimensions of other quantities, not excluding the dimension of a plane angle. See also Abstr. 5251 (1954).

J. W. T. WALSH

FUNDAMENTALS 530.1

530.1

5848. Symmetry of physical laws. III. Prediction and retrodiction. S. WATANABE. *Rev. mod. Phys.*, **27**, *No.* 2, 179–86 (*April*, 1955).

For Pt II, see Abstr. 3408 (1955). An attempt is made within the framework of the accepted quantum physics to achieve the maximum parallelism between prediction (inference of the future observational data from the present ones) and retrodiction (inference of the past observational data from the present ones). To implement this programme, it is shown that the "retrodictive state function" (extrapolation of the present data to the past) can be just as useful as the ordinary "predictive state function" (extrapolation of the present data to the future). This leads to a formalism in which time-reversal becomes a linear transformation and double time-reversal becomes a c-number. In spite of this formal symmetry, it can be shown that the actual success of a retrodiction depends on the satisfaction of an additional condition which is not required in prediction, and which is not always fulfilled. From the same point of view, a logical loophole is pointed out in the indiscriminate application of the H-theorem to the past. The so-called irreversibility of observation is interpreted in terms of the decrease of "information" in the process of inference. A.

530.1

5849. A note on the relativistic cut-off. H. T. FLINT AND E. M. WILLIAMSON. Letter in *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 354–5 (*April*, 1955).

See also Abstr. 7424 (1953). Flint's 5-dimensional

theory leads to a concept of a fundamental (minimum relativistic) length. This, in turn, provides a criterion for the vanishing of a relativistically invariant cutoff factor to be introduced into the quantum equations.

G. FIELD

530.112

5850. New analysis of the interferometer observations of Dayton C. Miller. R. S. SHANKLAND, S. W. MCCUSKEY, F. C. LEONE AND G. KUERTI. *Rev. mod. Phys.*, **27**, *No.* 2, 167–78 (*April*, 1955).

For nearly thirty years the results of the Michelson–Morley experiment obtained by Dayton C. Miller on Mount Wilson have stood at variance with all other trials of this experiment. As interest in Miller's results has continued to the present time, and since the original data sheets are available to the present writers, it seemed appropriate that the observations be subjected to a new analysis. It is now shown that the small periodic fringe displacements found by Miller are due in part to statistical fluctuations in the readings of the fringe positions in a very difficult experiment. The remaining systematic effects are ascribed to local temperature conditions. These were much more troublesome at Mount Wilson than those encountered by experimenters elsewhere, including Miller himself in his work done at Case in Cleveland. As interpreted in the present study, Miller's extensive Mount Wilson data contain no effect of the kind predicted by the ether theory and, within the limitations imposed by local disturbances, are entirely consistent with a null result at all epochs during a year.

A.

530.12

5851. Exact solutions of the Einstein–Maxwell field equations for static fields. J. EHLERS. *Z. Phys.*, **140**, *No.* 4, 394–408 (1955) In German.

The metric is taken to be $ds^2 = e^{2\psi}dx^{o2} - e^{-2\psi}dl^2$, the field equations being expressed as equations in the 3-space defined by dl^2 and solutions are derived for which this space is Euclidean. It is shown that if V is the potential of a classical electrostatic vacuum field, then $e^{-\psi} = 1 \pm \eta V$, where $\eta^2 = \kappa/2c^2$, and the relativistic potential is $V/(1 \pm \eta V)$. The relation of these results to known exact solutions is discussed.

R. A. NEWING

530.12

5852. Considerations on the Lorentz transformation and group property. A. METZ. *J. Phys. Radium*, **16**, *No.* 3, 206–10 (*March*, 1955) In French.

530.12

5853. Approximate equations for the Einstein–Schrödinger unified theory. M. LENOIR. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 13, 1400–2 (*March* 28, 1955) In French.

530.12

5854. Use of the flat-space metric in Einstein's curved universe, and the "Swiss-cheese" model of space. F. J. BELINFANTE. *Phys. Rev.*, **98**, *No.* 3, 793–800 (*May* 1, 1955).

Using a second metric tensor $\gamma_{\mu\nu}$ as proposed by Rosen, Gupta's supplementary condition for the gravitational field (which has the form of De Donder's co-ordinate condition) is written in general-covariant form. This supplementary condition appears to be of physical importance because of the use made of it by Gupta in the quantization of Einstein's gravitational field. This physical significance of the supplementary condition singles out a manifold of co-ordinate systems, which contains as sub-manifolds infinitely many metric spaces each allowing only "Lorentz transformations" leaving the $\gamma_{\mu\nu}$ constant. A particle is called "at rest" if it is not accelerated with respect to some of these "Lorentz" frames. Although the $\gamma_{\mu\nu}$-metric may be important in the formulation of the quantum theory of gravitons, it does not enter in the line element describing the results of physical measurements of time or distance, which are described by a line element containing as metric the gravitational tensor $g_{\mu\nu}$, so that space, flat with respect to hypothetical measurements by unrealistic rods keeping their γ-metric length on displacement, is actually found to be curved by physical measurements by realistic rods keeping their g-metric length on parallel displacement. The static spherically symmetric gravitational field $g_{\mu\nu}$ in empty space around a singularity "at rest" is obtained in terms of conventional polar co-ordinates in its "Lorentz" rest system in a form satisfying the supplementary condition. A simple relation is established between this new solution and the Schwarzschild solution for this static central field. The radial co-ordinate ρ used in the Schwarzschild solution, which is a convenient variable in the discussion of planetary motion, differs by a constant from the polar co-ordinate r in the "Lorentz" frame in which the point source of the field is at rest. Neither r nor ρ is equal to the radial distance R measured from the point source. If a picture of space is made on the γ-scale, then space has holes where masses are located. ("Swiss-cheese" models of space.) This fact may be helpful in eliminating divergences of field theory.

A.

530.12

5855. Special-relativistic derivation of generally covariant gravitation theory. R. H. KRAICHNAN. *Phys. Rev.*, **98**, *No.* 4, 1118–22 (*May* 15, 1955).

The Newtonian gravitation theory is generalized to an inhomogeneous wave equation for a tensor gravitational potential in Euclidean space-time by invoking the special relativity postulates of Lorentz invariance and equivalence of mass and energy. Under the assumption of Lagrangian derivability, this is found to lead uniquely to the generally covariant field theories (including the general relativity theory) augmented by four auxiliary conditions. Appendices treat the general definition of the energy tensor, and an empirically disqualified special relativistic scalar generalization of the Newtonian theory.

A.

530.12 : 532.51

5856. Contributions to the relativistic hydrodynamics. I. M. KHALATNIKOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11) 529–42 (1954) In Russian.

In anticipation of future applications to nuclear physics, the author studies the adiabatic, non-dissipative flow of liquids according to special relativity. It is shown that the equations of motion can be deduced from the principle of least action if action is defined as a contour integral along a 4-dimensional trajectory of the density of enthalpy. The rate of propagation of shock waves and second-order terms in the velocity of sound are derived by solving the

equations of motion. These equations are shown to admit solutions in terms of a potential of flow; their general solution for flow in one dimension is obtained.
R. EISENSCHITZ

530.12 : 537.591.1

5857. Relativistic transformations and the laws of conservation of energy/momentum. Applications to certain problems of the physics of cosmic rays. I. L. ROZENTAL'. *Uspekhi fiz. Nauk*, **54**, *No.* 3, 405–34 (1954) In Russian.

A general review of the topic. Among subjects treated are: the general scheme of kinematic transformation from a centre of mass to a laboratory system, disintegration into two particles and arising from this a study of criteria of correctness of various cases as consequences of disintegration. Also dealt with are the determination of the mass of a primary particle and of a secondary particle, the angular and energy distribution of particles transformed during disintegration, disintegration into three particles, experimental values for momentum, angle and energy spectra. Nineteen recent references. C. R. S. MANDERS

530.145

5858. Canonical invariance in Lagrangian quantum mechanics. W. K. BURTON. Letter in *Phys. Rev.*, **98**, *No.* 2, 555–6 (*April* 15, 1955).

Recent criticism [Abstr. 1554 (1955)] of Schwinger's variational formalism in quantum mechanics is refuted.
L. S. GODDARD

530.145

5859. Relativistic wave equations. H. FESHBACH. *Phys. Rev.*, **98**, *No.* 3, 801–2 (*May* 1, 1955).

A simple method for developing and reducing relativistic equations for particles of higher spin is briefly described. Some results obtained for systems with spin $\frac{3}{2}\hbar$ and $\hbar$ are stated. A.

530.145

5860. Configuration space methods in relativistic quantum field theory. I. A. S. WIGHTMAN AND S. S. SCHWEBER. *Phys. Rev.*, **98**, *No.* 3, 812–37 (*May* 1, 1955).

Three notions are introduced as a help in discussing the notion of particle in relativistic quantum field theory: particle interpretation, simple particle interpretation and relevant simple particle interpretation. The problem of finding all solutions of the Heisenberg–Dirac commutation rules and Jordan–Wigner anti-commutation rules for annihilation and creation operators is posed and its solution indicated on the basis of work by Gårding and Wightman. Observables of particle position, momentum and spin are introduced in accordance with the work of previous authors and the corresponding particle densities are expressed in terms of fields. The results disagree with those of previous authors. The relativistic transformation properties of fields are deduced from the corresponding properties for states in the case of no interaction. The use of "Schrödinger-type" relativity transformations makes this discussion completely elementary and makes possible a treatment of time inversion no more complicated than for other relativity transformations. The Schrödinger-type charge conjugation transformation is also discussed.
A.

530.145

5861. Low frequency divergence in quantum field theory. D. ITO AND H. TANAKA. *Sci. Rep. Yokohama Nat. Univ. I*, *No.* 3, 54–66 (*March*, 1954).

The divergences due to the energy conservations in the intermediate states are considered from the point of view of the graphical structure and of the field reactions. A.

530.145

5862. On the causal development of bound systems with relative time. V. N. TSYTOVICH. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 372–4 (1955) In Russian.

Two particles of equal mass are considered to interact through an instantaneous potential. Propagation of positive and negative frequency parts of the wave-function with respect to time is discussed.
G. E. BROWN

530.145

5863. Angular momentum in non-spherical fields. A. DE-SHALIT. *Nuclear and meson physics* [*Glasgow*] 129–30. See Abstr. 6379 (1955).

A field angular momentum is constructed so that the sum of it and the particle momentum is conserved. This is useful if one has to consider the closed system of particle plus field. G. E. BROWN

530.145

5864. On quantum field theories. R. HAAG. *K. Danske Vidensk. Selsk., mat.-fys. Medd.*, **29**, *Paper* 12, 37 *pp.* (1955).

The general conditions which a relativistic quantum theory of interacting particles must satisfy are investigated and brought into mathematical form. Some difficulties connected with the infinite number of degrees of freedom are pointed out; especially, the fact that the canonical commutation relations no longer have unique solutions must be taken into account in all discussions of field theory. It is shown that the "free field vacuum" of the Tamm–Dancoff method and Dyson's matrix $U(t_1, t_2)$ for finite t_1 or t_2 cannot exist. The possibility of a conventional field theory in which the fields commute for equal times is investigated. A.

530.145

5865. Indefinite metrics and multi-mass field theories. R. J. N. PHILLIPS. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 822–39 (*May*, 1955).

An analysis of quantum-theoretical scalar products is made, and a philosophy for treating indefinite scalar products is developed. This is applied in a study of positive-energy multi-mass fields. It is found that in general the multi-mass formalism confers no improved convergence; although convergent theories can be constructed in principle, it is not possible to do so in practice. The theories that can be used are at least as divergent as in the single-mass formalism. A.

530.145

5866. Soluble problem in the theory of Coulomb excitation. L. C. BIEDENHARN AND C. M. CLASS. *Phys. Rev.*, **98**, *No.* 3, 691–3 (*May* 1, 1955).

The quantum treatment of Coulomb excitation in the limiting case of no energy loss involves radial Coulomb integrals that can be expressed in simple terms. The excitation function, G, and particle parameter for the directional correlation, a_2, are evaluated for this case and compared to the classical

limit. The deviation from the classical limit is found to be negligible for the excitation function in the region of experimental interest, but for the particle parameter a_2 the deviation is sizeable. A.

530.145

5867. Commutation relations between different fields. H. UMEZAWA, J. PODOLANSKI AND S. ONEDA. *Proc. Phys. Soc.* [*London*] *A*, **68,** *Pt* 6, 503–11 (*June*, 1955).

The commutation relations between fields representing different particles are not, as has been suggested, arbitrary. In general, only certain types of commutation relations are compatible with a specified Hamiltonian. The restrictions on the commutation relations—arising from the requirement of canonical invariance of field theory—are derived. Further restrictions can be imposed by the assumption that the fermions form "families." A family comprises a set of mutually anticommutating particle fields. Members of different families commute. As a consequence of the family postulate bosons commute with fermions. It is shown that the family postulate is consistent with the restrictions imposed by canonical invariance and that the two requirements together fix uniquely the commutation relations of the baryon-π system. A.

530.145

5868. On the Feynman principle. J. C. POLKINGHORNE. *Proc. Roy. Soc. A*, **230,** *No.* 1181, 272–6 (*June* 21, 1955).

The formulation of quantum field theory in terms of the Feynman principle is discussed. It is shown that the operators defined in terms of this principle satisfy the equations of motion. A definition of canonically conjugate momenta is given in terms of the principle and is shown to be equivalent to the usual definition. The canonical commutation relations are then deduced and the equivalence of this formulation and the canonical formalism is thereby established. The equations for Feynman amplitudes are also obtained. In conclusion some difficulties of the theory and some possible extensions are discussed. A.

530.145

5869. Vacuum polarization and proton-proton scattering. L. L. FOLDY AND E. ERIKSEN. *Phys. Rev.*, **98,** *No.* 3, 775–9 (*May* 1, 1955).

An attempt is made to verify the presence of effects due to vacuum polarization in available experimental data on proton-proton scattering. In spite of the smallness of these effects and relatively large errors in the data, it appears that the data substantiates the predicted effects of vacuum polarization on the electrostatic interaction of two protons, particularly on the assumption of a Yukawa shape for the nuclear potential. By correcting the available data for these effects, new values are obtained for the zero-energy scattering length and effective range of the nuclear interaction between two protons. The results in the notation of Blatt and Jackson are: $-R/a = 3{\cdot}704$, $r_0 = 2{\cdot}76\times10^{-13}$ cm. A.

530.145

5870. Zero-energy mesonic processes and renormalization in D.T.G.'s formalism. S. CHIBA AND M. NAMIKI. Letter in *Progr. theor. Phys.*, **12,** *No.* 5, 693–4 (*Nov.*, 1954).

Renormalization is set up using the formalism of Deser, Thirring and Goldberger [Abstr. 6296 (1954)], but with infinite constants defined by direct analogy with electrodynamics. An expression for zero-energy meson-nucleon scattering is derived and also the Kroll–Ruderman theorem [Abstr. 3118 (1954)]. P. T. MATTHEWS

530.145

5871. Zero energy mesonic processes and renormalization in Schwinger's formalism. M. NAMIKI, S. CHIBA AND S. HANAWA. Letter in *Progr. theor. Phys.*, **12,** *No.* 5, 694–5 (*Nov.*, 1954).

The results of the preceding abstract are rederived using the formalism of Schwinger [Abstr. 64 (1952)]. P. T. MATTHEWS

530.145

5872. Velocity-dependent potential and gauge invariance of the first kind. C. H. CHANG. Letter in *Progr. theor. Phys.*, **12,** *No.* 5, 696 (*Nov.*, 1954).

In one-dimensional problems a velocity-dependent potential may be transformed into a velocity-independent potential by introducing a space-dependent phase factor in the wave-function. This is only true in three dimensions under certain conditions. P. T. MATTHEWS

530.145

5873. Scattering of mesons by nucleons in the theory of radiation damping. A. S. MARTŸNOV. *Zh. éksper. teor. Fiz.*, **28,** *No.* 3, 287–90 (1955) In Russian.

Meson energies of 42 and 112 MeV are considered in detail. Qualitative features of the experimental results can be reproduced, but quantitative agreement is not good. Within the framework of perturbation theory, the damping contributes only a small correction to the undamped result. G. E. BROWN

530.145

5874. On the meaning of the solution to the one-body Dirac equation. S. TANI AND K. YAMAZAKI. *Progr. theor. Phys.*, **12,** *No.* 6, 723–46 (*Dec.*, 1954).

Attempts to give another demonstration of a theorem concerning a fermion interacting with an external field; this theorem, which is first shown by Furry, states that in the treatment of the interaction with external fields it is sufficient for one to know the complete set of the solutions to the one-body Dirac equation, even when the fermion field is quantized according to the hole theory for negative energy states. The demonstration rests on the examination of the effects which are generated by a special type of canonical transformation on the Hamiltonian of the system. But the knowledge of the one-body solution is insufficient to predict the results of the hole theory, when the fermion is interacting with a quantized boson field. By the further examination of the transformation similar to the above, it is possible to find to what extent the one-body solution is efficient in the whole scheme of quantized fields. Using some techniques of the operator calculus, a method is described for computing exactly, at least formally, the correction terms coming from the effects of the negative-energy sea of fermions. The effects of the hole-theoretical vacuum may be classified into two kinds; one is due to the genuine vacuum polarization which comes into play in the calculation in the

form of spur expressions (and is represented by closed loops in Feynman diagrams), and the other is due to the exclusion principle which acts on the negative-energy intermediate states (and plays its rôle in the process represented by connected one-line Feynman diagrams). Formal procedures for computing the latter type of corrections to the one-body solution are explained by the example of nucleon field interacting with neutral pseudoscalar meson field. The four-dimensional aspect of the problem and the invariance to the charge conjugation are also considered. A.

530.145

5875. Conservation of parity and the new particles. R. Utiyama and W. Tobocman. *Phys. Rev.*, **98**, *No.* 3, 780–2 (*May* 1, 1955).

It is pointed out that the conservation of parity can lead to certain conservation rules for multiple particle theories. These rules involve only the intrinsic parities and the numbers of particles present. The existence and precise forms of such conservation rules will depend on the form of the interaction Lagrangian. An example is given to show how such considerations may play a rôle in cataloguing the unstable particles. A.

530.145

5876. The cut-off method in meson theory. S. Goto. *Progr. theor. Phys.*, **12**, *No.* 6, 699–712 (*Dec.*, 1954).

The method is adopted not only for convenience but also on physical grounds, in view of its recent successful application of the method to the analysis of the low-energy meson processes. From this standpoint, the anomalous magnetic moments of the nucleons and the γ-decay of the neutral pions have been re-examined, with improved results. The anomalous magnetic moment of the electron is also re-examined for the purpose of comparison of meson theory with quantum electrodynamics. A.

530.145

5877. Kinematical investigation of the *S*-matrix. M. Kawaguchi. *Progr. theor. Phys.*, **12**, *No.* 6, 758–66 (*Dec.*, 1954).

A general method is proposed for investigating the kinematical properties of the *S*-matrix in a covariant manner, independent of the method of approximation and the type of interaction. The *S*-matrix is separated into a definite number of independent bases, i.e. the kinematical parts and their dynamical coefficients. The number and types of such kinematical bases are obtained for one-fermion problems and boson-decay processes. As an application some absolute selection rules for three-body decays can be derived. For example, a spin 0 particle cannot decay into three photons, any two making an angle of 120° with each other. The same result holds for the decay of a spin 1 particle into three identical spin 0 particles. Some of the results are useful for analysing the decay of τ-meson. A.

530.145

5878. Pion–nucleon scattering in the Tamm–Dancoff approximation. S. Chiba, M. Yamazaki and N. Fukuda. *Progr. theor. Phys.*, **12**, *No.* 6, 767–88 (*Dec.*, 1954).

The pion–nucleon scattering is treated in the Tamm–Dancoff approximation using the symmetrical ps-ps theory, with emphasis particularly on the renormalization procedure. The number of mesons and nucleon-pairs is restricted up to two and one, respectively, in every intermediate state. In order to perform the renormalization consistently, it is required to adopt the five-box approximation of Bethe and Dyson. But even in this case, the meson self-energy term is not treated consistently and should be discarded. A method is proposed to remove the overlapping divergences and it is shown that the Salam's procedure can be carried out in a closed form. The scattering phase shifts are evaluated and compared with experiments. A.

530.145

5879. On the relation between meson–nucleon scattering and photomeson production. M. Kawaguchi and S. Minami. *Progr. theor. Phys.*, **12**, *No.* 6, 789–801 (*Dec.*, 1954).

Using the unitarity of the *S*-matrix, Aizu and Watson have shown some relations between the photomeson production and the meson–nucleon scattering. Their theory is reformulated and generalized here in a summarized form, in order to facilitate the analysis of experimental results. Experiments on the photomeson production near threshold energy lead one to suggest some limits on the magnitude of *s*-phase shifts of the meson–nucleon scattering and on the contribution of the nucleon current. A.

530.145

5880. On the theory of pseudoscalar mesons in pseudovector coupling with a nucleon field. F. Penzlin. *Z. Naturforsch.*, **10a**, *No.* 3, 216–19 (1955) In German.

It is shown that this interaction cannot be renormalized by the device suggested by Ning Hu [Abstr. 3337 (1951)]. P. T. Matthews

530.145

5881. On non-linear meson theory. G. Eder. Note in *Z. Naturforsch.*, **10a**, *No.* 3, 255 (1955) In German.

With the constants set for the carbon nucleus, the non-linear meson theory of Schiff [Abstr. 9279 (1951)] and Thirring [Abstr. 7046 (1952)] is shown to give a much too large scattering cross-section for 62 MeV pions. G. E. Brown

530.145

5882. Survey of nuclear forces. H. S. W. Massey. *Nuclear and meson physics* [*Glasgow*] 1–10. See Abstr. 6379 (1955).

The effective range theory for low-energy nucleon–nucleon scattering is reviewed and values of the parameters are given on the basis of recent experiments. High-energy nucleon–nucleon experiments are reviewed. Processes involving more than two bodies are discussed briefly. G. E. Brown

530.145

5883. Present status of meson theory of nuclear forces. M. M. Levy and R. E. Marshak. *Nuclear and meson physics* [*Glasgow*] 10–23. See Abstr. 6379 (1955).

A brief report incorporating a survey of results given by the Tamm–Dancoff method for pseudoscalar mesons in pseudoscalar coupling. G. E. Brown

530.145

5884. Classical motion of the nucleons in a scalar meson field. G. Szamosi and G. Marx. *Acta phys.* [*Hungar.*] **4**, *No.* 3, 219–36 (1955).

Deals with the classical motion of a point nucleon in a scalar meson field. The motion in a static field can be subjected to exact treatment. The calculations confirm Werle's results obtained for small-energy approximation according to which a purely attractive (e.g. Yukawa) potential will lead to repulsion if the absolute value of the potential energy becomes greater than the proper energy. The existence of a repulsive sphere of a radius approximately equal to the nucleon's Compton wavelength around the nucleon is thereby proved without recourse to any special assumption. A study of the course of motion in time leads to the result that the particle crosses the boundary of the repulsive region with the velocity of light. In the case of the interaction of several nucleons, effects analogous to three-body forces take place. A.

530.145

5885. The optical model and the nucleon–nucleon scattering. A. Kind and C. Villi. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 749–51 (*April*, 1955).

The general features of the energy dependence of the potential, in the optical model of neutron scattering by nuclei, are deduced from the independent particle model, using a Yukawa potential between the incident nucleon and the individual nucleons of the nucleus. P. T. MATTHEWS

530.145

5886. Self-energy effects on meson–nucleon scattering according to the Tamm–Dancoff method. J. C. Taylor. Letter in *Phys. Rev.*, **98**, *No.* 1, 201 (*April* 1, 1955).

Visscher [Abstr. 739 (1955)] has shown that self-energy effects give rise to an unphysical pole in the above problem. A modification of the usual way of eliminating the negative frequency components removes this difficulty. P. T. MATTHEWS

530.145

5887. Possible experiments to determine the transition matrix for *p-p* scattering. R. Oehme. Letter in *Phys. Rev.*, **98**, *No.* 1, 216–17 (*April* 1, 1955).

The S-matrix for p-p scattering at a given energy depends on nine real parameters. It is possible to obtain eleven relations between these, provided one can perform single, double and triple scattering experiments. The targets are always unpolarized and only one hydrogen scattering is necessary.

P. T. MATTHEWS

530.145

5888. Applications of causality to scattering. R. Karplus and M. A. Ruderman. *Phys. Rev.*, **98**, *No.* 3, 771–4 (*May* 1, 1955).

The optical dispersion relations are extended to the scattering of massive particles and are applied to the nuclear interaction of the pion-nucleon system. The sign of the forward scattering amplitude is unambiguously inferred from measured total cross-sections and found to agree with that determined from Coulomb interference. A.

530.145

5889. Classical field theory of nuclear forces. M. H. Johnson and E. Teller. *Phys. Rev.*, **98**, *No.* 3, 783–7 (*May* 1, 1955).

An attempt to explain nuclear properties with the help of a classical nuclear potential whose quanta are π-mesons leads to involved non-linear interactions. A potential was therefore used whose quanta are neutral scalar mesons. Saturation properties, empirical binding energies and observed nuclear densities are obtained if the potential depends on the velocity of the nucleons. This velocity dependence accounts for a number of additional nuclear properties. A.

530.145

5890. Lattice space quantization of coupled meson and nucleon fields. D. H. Holland. *Phys. Rev.*, **98**, *No.* 3, 788–93 (*May* 1, 1955).

The lattice space quantization method used by Schiff for treating non-linear mesons is used in quantizing coupled meson and nucleon fields. Neutral pseudo-scalar mesons with pseudo-scalar coupling to neutral Dirac nucleons are assumed. Only the fields at the lattice points of a cubic lattice are considered. An appropriate lattice space Hamiltonian is found and momentum (gradient) terms are treated as perturbations. To zero order the lattice points are uncoupled, so the state function can be written as a product of functions describing a single point. In the representation chosen, finding a particular point function entails the solution of a set of coupled differential equations. These equations can be solved in principle with no assumptions as to the magnitude of the coupling constant g but require numerical integration, and have not been solved. Linear combinations of the zero-order solutions are found which diagonalize the perturbation to lowest order and can be interpreted as one-particle momentum eigenstates. The perturbation energy of these states includes a term proportional to k^2 which is interpreted as the kinetic energy. Linear combinations of two-particle momentum eigenstates are found which approximately diagonalize the perturbation and, from these, scattering cross-sections are calculated. The lattice constant l appears in the final results and must be regarded as a parameter of the theory. In order that the perturbation approximation be valid, l must be much larger than the meson Compton wavelength. A.

530.145

5891. Structure of the scattering matrix. Y. Nambu. *Phys. Rev.*, **98**, *No.* 3, 803–11 (*May* 1, 1955).

It is shown that in field theory the structure of the scattering matrix for a certain variety of processes, such as those between a meson and a nucleon, a photon and a charged particle, etc., can be analysed making use of relativistic invariance and microscopic causality. General formulae have been obtained which enable one to express scattering matrices for real as well as virtual processes explicitly by means of a parametric representation. The ideas are closely related to those which have been used by several authors in the analysis of the Green's functions for interacting fields. A.

530.145

5892. On the relativistic equation for scattering. N. KEMMER AND A. SALAM. *Proc. Roy. Soc. A*, **230**, *No.* 1181, 266–71 (*June* 21, 1955).

By defining an analytic continuation method, Wick has been able to elucidate the structure of the relativistic equation for bound states. In particular, the equation acquires an "elliptic" rather than a "hyperbolic" metric. Taking advantage of a gap in the rest-mass spectrum of one-nucleon states, a similar investigation is here carried through for the relativistic equation for two-nucleon scattering, in the energy region $2\kappa < E < 2\kappa + \mu$, κ and μ being nucleon and meson masses. A.

530.145

5893. Meson theory and nuclear matter. T. H. R. SKYRME. *Proc. Roy. Soc. A*, **230**, *No.* 1181, 277–86 (*June* 21, 1955).

An attempt is made to justify the use of the concept of a "mesic fluid" in connection with the structure of nuclear matter. A transformation is made of the usual symmetric pseudo-scalar meson theory to bring into evidence certain saturation properties, which provide a natural basis for the use of a "self-consistent" field in the discussion of nuclear structure. Fluctuations about this semi-classical saturated state will give rise to residual interparticle forces within the nucleus, and are also briefly considered in relation to electromagnetic interactions. A.

530.145 : 539.18

5894. On multiple production of mesons by high energy nucleon collisions. NING HU. *Scientia Sinica*, **3**, *No.* 4, 387–404 (*Dec.*, 1954).

A qualitative argument is given for the theory that in the high-energy collision between nucleons the mesons in the "cloud" outside a certain radius are stripped off, giving rise to multiple production. The shape of the meson cloud surrounding a nucleon is estimated for pseudo-scalar mesons with pseudo-vector coupling, using a type of Bloch–Nordseick method. The results of the theory are compared with experimental data, and with the predictions of other theories. P. T. MATTHEWS

530.145 : 778.34

5895. Theory of scattering of fast charged particles. III. The multiple scattering from tracks with consideration of statistical coupling. G. MOLIÈRE. *Z. Naturforsch.*, **10a**, *No.* 3, 177–211 (1955) In German.

This is a comprehensive and useful article for investigators using photographic plate techniques. Various criteria used to determine multiple scattering are considered. In all of these the track is first divided into cells. The criteria discussed here are: The angle between neighbouring tangents (Case I*a*) or chords (Case II*a*); the angle between successive "best lines" (Case I*b*) and connecting lines of the centres of gravity (Case II*b*), i.e. the sagitta method. The distribution function of the criteria is formulated for each case inclusive of the statistical coupling between criteria. For cases I*b* and II*b* the effect of "noise" is considered. Means of practical evaluation of the functions involved are indicated and the necessary tables are given. Methods of separating "noise" from the scattering are indicated. For previous papers see Abstr. 5545, 7037 (1952). G. E. BROWN

530.145

5896. On the divergence of the perturbation method in field theory. S. F. EDWARDS. Letter in *Phil. Mag.*, **46**, 569–70 (*May*, 1955).

The one-particle propagator may be expressed as the ratio of two power series. In a previous discussion [Abstr. 8932 (1954)] the effects of vacuum polarization were neglected. This approximation is here removed. In a cutoff theory the series have a finite radius of convergence for Fermi–Bose, but are only asymptotic for Bose–Bose interactions. P. T. MATTHEWS

530.162

5897. Indeterminacy in quantum mechanics according to its formulation as a statistical theory. G. P. DISHKANT. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 1, 117 (1955) In Russian.

Elaborating the theory of quantum mechanical distributions in phase space, Moyal [Abstr. 3759 (1949)] asserts that a distribution function which at any time is non-negative stays so for all times; this persistency of sign is considered as being a deterministic feature of the theory. The author criticizes Moyal's result, claiming that it is due to a mistake in the deduction. R. EISENSCHITZ

530.162

5898. Wave-function for the ground state of an assembly of bosons with mutual interaction. N. N. BOGOLYUBOV AND D. N. ZUBAREV. *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 129–39 (1955) In Russian.

Hamilton operator, wave-function and energy are expanded in powers of a small parameter which vanishes in the limit of vanishing interaction. The wave equation is transformed by substituting new independent variables as previously defined [Abstr. 754 (1955)]. These variables (Fourier coefficients of density) are used for expressing the unperturbed wave-function of the ground state in a relatively simple form. The unperturbed Hamilton operator is obtained in a form that is similar to the expression found by second quantization; it is, however, interpreted by the authors in terms of the energy of photons. Corrections of the energy and wave-functions are proportional to the square of the small parameter and are obtained in a relatively simple form. Discussing results obtained by other authors, superiority is claimed for the method employed in the present paper. R. EISENSCHITZ

530.162

5899. The statistical description of assemblies with collective interaction. I. Foundations and limitations of the collective description. G. ECKER. *Z. Phys.*, **140**, *No.* 3, 274–92 (1955) In German.

Whereas the theoretical formulation of charge systems containing a finite number of mono-energetic streams offers no difficulty in principle, the analysis of assemblies with random motion has led to as yet unresolved discrepancies. These are attributed to an insufficient consideration of the assumptions underlying the models on which the analyses are based. The distribution function for a finite assembly is meaningful only with reference to finite intervals in phase space and time. The application of the Boltzmann transfer equation imposes two sets of conditions, setting both upper and lower bounds for

the order of magnitude of these intervals. The collective description is valid only if these conditions are satisfied simultaneously. The frequently used model, in which the individual charges are assumed dispersed or "smeared out" over their immediate vicinity (referred to as the "D-model"), corresponds to the case when the lower bounds on the phase space and time intervals are allowed to approach zero. Two similar sets of conditions are set up to delineate the regions where the collision term can be calculated as a collective effect, from those where individual particle considerations are dominant. It is emphasized that the conditions for the validity of the collective description as applied to the statistical dynamical equations, and as applied to the collision term are not identical. E. A. ASH

530.162

5900. The statistical description of assemblies with collective interaction. II. The significance of the limitations of the validity of the D-model for the comprehension of, and for the results obtained by the collective description. G. ECKER. *Z. Phys.*, **140**, *No.* 3, 293–307 (1955) In German.

A criterion for the range of validity of the Vlasov approximation [*Journal of Physics, U.S.S.R.*, **10**, 25, (1945)], is obtained in terms of the order of magnitude of the ratio of the force resulting from the collective to that resulting from individual particle interaction. The requirements for the validity of the collective description found in Pt I are imposed. The criterion is found to have a different functional dependence on temperature and density to that suggested by Vlasov, or that by Bohm and Pines [Abstr. 5379 (1951)]. It is shown to be a function also of the amplitude of the disturbance, so that the range of the validity of the collective description decreases as the amplitude of the disturbance decreases. It is shown further that the singularity occurring in the dispersion relations found by previous authors arises in a region for which the considerations of Pt I indicate that the collective description cannot be validly applied. Finally the discrepancies between the dispersion relations obtained by the Laplace transform on the one hand, and by the substitution of an assumed harmonic dependence on the other, are also resolved by excluding from the integrals in velocity space those regions in which the collective description is not justified. E. A. ASH

530.162 : 536.7

5901. Stability of the homogeneous phase. I. General theory. I. Z. FISHER. *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 171–80 (1955) In Russian.

Develops from the theory of the radial function of distribution the necessary conditions for thermodynamical stability and sufficient conditions for thermodynamical instability of a homogeneous phase. It is found that Bogolyubov's [*Problems of dynamical theory in statistical physics*, Gostekhizdat, 1946] equation

$$-kT\ln g(r) = \Phi(r) + \frac{\lambda}{r}\int_0^\infty \left[\int_{|r-\rho|}^{r+\rho} E(t)tdt\right][g(\rho) - 1]\rho d\rho$$

is only true if $r[g(r)-1]\to 0$ when $r\to\infty$. Hence the correct mathematical problem of finding the radial function of distribution $g(r)$ from the given intermolecular potential $\Phi(r)$ and thermodynamical parameters T and λ consists in solving a problem of the eigenvalues of λ and eigenfunctions $g(r;\lambda)$ in Bogolyubov's equation, making allowance for the supplementary condition referred to above. F. LACHMAN

530.162 : 536.7

5902. On the Ising problem and Mayer's cluster sums. G. S. RUSHBROOKE AND H. I. SCOINS. *Proc. Roy. Soc. A*, **230**, 74–90 (*June* 7, 1955).

When Mayer's imperfect-gas formalism is applied to the Ising problem emphasis is focused on certain irreducible cluster sums, β_k. It is shown that there is no contribution to β_k unless the $k+1$ systems concerned occupy a set of lattice sites which are themselves either (*a*) a single point, (*b*) a pair of neighbouring points or (*c*) multiply-connected on the lattice. Each β_k is the sum of such contributions. The familiar quasi-chemical approximation results from neglecting all contributions to the β_k from multiply-connected sets of occupied lattice sites. A second approximation, involving the smallest of such multiply-connected sets of occupied sites, can always be carried through explicitly. A.

530.162 : 536.75 : 621.391

5903. On the definition of entropy in information theory. A. TORTRAT. *Ann. Télécomm.*, **10**, *No.* 2, 39–47 (*Feb.*, 1955) In French.

The validity of the usual definition of entropy when applied to continuous signals is questioned. Several specific situations are considered and the limitations of the definition demonstrated. An extensive mathematical appendix discusses the orthogonality and convergence of certain series employed in the analysis. J. M. C. DUKES (R)

530.162

5904. Information required for missile guidance. F. P. ADLER. Letter in *J. appl. Phys.*, **26**, *No.* 4, 492 (*April*, 1955).

Shows that in the case of straight-line target motion and of an aimed missile, the average information rate for guidance is 0·75 bits/sec; if evasive action is allowed for, this becomes 1·8 bits/sec. This contrasts with a typical speaking rate of 30 bits/sec. T. J. REY

MECHANICAL MEASUREMENTS 531.7

531.754.2

5905. Powder density measurement by gas burette. A. NISHIOKA AMD K. SEKIKAWA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 5, 873–4 (*Sept.–Oct.*, 1954).

The cell containing the powder is evacuated and then put into communication with a tube leading to one limb of a gas burette. The mercury level in the burette is then adjusted until the level is the same in both limbs; the change in volume is equal to the difference between the cell volume and the specimen volume. Hence the volume and so the density of the specimen; an accuracy of 1–2% is claimed. J. M. HOUGH

531.76

5906. Precision measurement of time. H. M. SMITH. *J. sci. Instrum.*, **32**, *No.* 6, 199–204 (*June*, 1955).

The fundamental standard of time is made available by means of radio time signals controlled from an observatory. Local time standards may be in the form of chronometers, pendulum clocks or, often more conveniently, quartz crystal clocks. Various forms of chronograph are available enabling events to be recorded in terms of the time scale provided by the local standard. Drum and tape chronographs are simple, robust and of adequate accuracy for many purposes: printing and photographic chronographs possess the advantage of eliminating the need for measurement. Despite the disadvantages involved in employing photographic processes, this form of timing has been found advantageous in, for example, the photographic zenith tube telescope. Interval timers, employing the charge or discharge characteristics of a condenser, are available in convenient portable forms. Specialized cameras have been designed for timing field and track events, and may well find applications in scientific work. An accurate chronograph using a Kerr cell is also described. Decimal counter chronometers are available in various forms, some of which employ cold-cathode tubes. Brief reference is made to oscillographic methods of timing, and two examples are quoted from the work of the Royal Observatory. The review closes with some comments on the present proposals for a new definition of the unit of time. A.

MECHANICS OF FLUIDS 532

532.137 : 539.32

Apparatus for low-frequency dynamic measurement on polymeric systems. *See Abstr.* 6551

532.51

5907. The forces on a circular cylinder moving with low speeds in a semi-infinite viscous liquid bounded by a plane wall. Y. TAKAISI. *J. Phys. Soc. Japan*, **16**, *No.* 5, 407–15 (*May*, 1955).

The steady slow motion of a circular cylinder in a semi-infinite viscous liquid bounded by a plane wall is discussed on the basis of Oseen's linearized equations of motion, assuming that the cylinder is moving parallel to the bounding wall. The forces acting on the cylinder are calculated to Lamb's approximation. By carrying out detailed numerical calculations, it is shown that at sufficiently small Reynolds numbers the drag on the cylinder is of the Stokes's type, as in the case of White's experiments on metal wires moving with low speeds in a viscous liquid bounded by two parallel plane walls. It is also shown that the cylinder experiences a repulsive force from the bounding wall. A.

532.51

5908. Rayleigh's problem for a cylinder of arbitrary shape. II. H. HASIMOTO. *J. Phys. Soc. Japan*, **16**, *No.* 5, 397–406 (*May*, 1955).

For previous part, see Abstr. 9962 (1954). Discusses the frictional force on an arbitrary cylinder which starts to move suddenly from rest with uniform velocity W in the direction of its length. By using the WKB method, a new asymptotic expansion formula in powers of $[\sqrt{(\nu t)}]/R$ is derived for the frictional drag τ on a cylinder with no corners, where ν is the kinematic viscosity, t is the time measured from the start, and R is the local radius of curvature of the surface measured inwards. The first approximation gives the naturally expected value $(\mu W)/[\sqrt{(\pi \nu t)}]$ for the frictional drag per unit area, which is the same as that for a flat plate of infinite breadth. As far as the second approximation the total frictional drag on the cylinder is the same as that on a circular cylinder with the same perimeter, and is in accord with the results recently obtained by Batchelor. The effect of the variation of the curvature along the surface on the local friction first appears in the fourth order of approximation. The correction due to the presence of corners is made in the second approximation, and some errors in Batchelor's paper are corrected. For the intermediate value of νt the drag calculated by these formulae shows a good agreement with that calculated by the formulae in powers of $(\nu t)^{-1}$ as given in the previous part. A.

532.51 : 530.12

Contributions to the relativistic hydrodynamics. *See Abstr.* 5856

532.51 : 535.557

5909. Flow birefringence as a technique for the study of hydrodynamic fields. J. H. WAYLAND. *J. Phys. Radium*, **16**, *No.* 3, 27 S–29 S (*March*, 1955) In French.

Some results of an investigation into the possibility of using flow birefringence methods for studies of turbulence in liquids are given. The liquid used is bentonite, which is examined in linearly polarized light when held in a 2 mm gap formed between two concentric cylinders. The outer cylinder is fixed and the inner made to rotate at speeds such that turbulent flow occurs. Graphs are given showing how the angle of extinction and the magnitude of the birefringence varies across the gap. The results are discussed in relationship to previously published observations [Signer and Gross, *Z. phys. Chem.*, **165A**, 161 (1933); Buchheim, Stuart and Menz, *Z. Phys.*, **112**, 407 (1939); Jerrard, Abstr. 112 (1951)]. The necessity of avoiding the reflection of light from the cylinder walls is stressed. This is done by coating them with Teflon. H. G. JERRARD

532.51 : 538.56

Reflection and refraction of hydromagnetic waves. *See Abstr.* 6316

532.516

5910. Coefficients of viscosity for a fluid in a magnetic field or in a rotating system. G. J. HOOYMAN, P. MAZUR AND S. R. DE GROOT. *Physica*, **21**, *No.* 5, 355–9 (*May*, 1955).

The linear equations between the elements of the viscous pressure tensor and the rates of deformation are investigated for the case of an isotropic fluid in an external magnetic field or for the equivalent case of a rotating fluid. Since these equations can be incorporated within the thermodynamics of irreversible processes, the Onsager reciprocity relations hold for

the scheme of phenomenological coefficients. For the present case the viscous behaviour is seen to be described by 8 coefficients between which one Onsager relation exists. The remaining 7 independent coefficients can be combined in a linear way so as to yield 5 coefficients of ordinary viscosity, the other 2 coefficients then describing the volume viscosity and a cross-effect between the ordinary and the volume viscosity, respectively. For the special case of vanishing volume viscosity the equations are compared with those derived from kinetic theory by Chapman and Cowling for an ionized gas in a magnetic field. A.

532.517

5911. Two flow problems in a viscous fluid. A. ANZELIUS. *Ark. Fys.*, **9**, *Paper* 27, 391–8 (1955).

An approximate solution to the stream function ψ for a viscous fluid is obtained by expanding in powers of ρ/μ. The streamlines $\psi = \text{const.}$ are given for a sector and a strip. A.

532.517

5912. Equivalent-radius method for determination of non-Newtonian flow curves from viscometric data. K. H. CRAM AND J. C. WHITWELL. *J. appl. Phys.*, **26**, *No.* 5, 613–18 (*May*, 1955).

A rapid and precise method is presented for approximating absolute flow curves (shear rate *v.* shear stress) of non-Newtonian liquids from data obtained with rotational or capillary viscometers. It is shown that the apparent Newtonian flow curve computed from a single measurement (i.e. a single flow rate) in either type of viscometer crosses the true flow curve at a shear stress corresponding to some intermediate radius between the bob and cup radii or less than the capillary radius. If shear rate and stress are computed at the common point using the ordinary Newtonian relations for shear stress and shear rate, the point so calculated will lie on the absolute flow curve. An "equivalent radius" rather than a wall radius is used in the conventional Newtonian equations. The position of the equivalent radius is fairly insensitive to changes in the form of the flow curve, particularly in the case of the rotational viscometer. A method for determining the proper intermediate radius is developed and graphs are presented to facilitate this determination and permit estimation of the accuracy of the method. An example is given using data from the literature for a 62·2% GR-S latex slurry. Within the range of the data (slope of the log-log flow curve varying from 1·5 to 3·0), the maximum error incurred by use of a single equivalent radius for each of two rotational viscometers was 0·1% for the instrument with a cup/bob radius of 1·064 and 0·4% for the instrument with a ratio of 1·113. Accuracy can be increased by use of an iterative procedure. The method has been developed in detail only for the case of pseudo-plastic flow, but the principle can be applied to other types of flow. A.

532.52 : 532.632

5913. On the dynamics of small vapor bubbles in liquids. S. A. ZWICK AND M. S. PLESSET. *J. Math. Phys.*, **33**, *No.* 4, 308–30 (*Jan.*, 1955).

The equations of motion for a small (not observable) spherical vapour bubble, are derived and applied to cases of a bubble expanding in a superheated liquid and a bubble collapsing in a liquid below its boiling point. The heat transfer across the bubble boundary is considered. An asymptotic solution of the equations of motion, valid when the bubble becomes large (observable) has been presented previously together with experimental verification [Abstr. 5541 (1954)]. H. C. COLE

532.57 : 621.318.3

5914. Electromagnetic pumps and flowmeters. M. GREENHILL. *Atomic Energy Res. Establ.* [*Harwell*] *Inf. Bib.*, *No.* 93, 4 *pp.* (1955).

A second edition of the bibliography reported in Abstr. 10847 (1954), with 8 additional references.

532.58

5915. Shock waves in a dense medium. I. Reference to some theoretical considerations. J. KIEFFER, J. DAPOIGNY AND B. VODAR. *J. Rech. Cent. Nat. Rech. Sci.*, **6**, 137–46 (*March*, 1955) In French.

Hugoniot's adiabatic-dynamic relations are derived, and applied to discuss the essential differences between shock-waves in a gas and in a liquid, and the theory is applied to discuss the production of high densities by the collision and reflection of shock waves. The paper is to be followed by a second giving experimental results obtained by the authors.

J. S. G. THOMAS

532.58

5916. Experimental determination of the thickness of weak shock fronts in liquids. W. M. FLOOK, JR AND D. F. HORNIG. *J. chem. Phys.*, **23**, *No.* 5, 816–21 (*May*, 1955).

The thickness of weak shock fronts, across which the pressure difference was in the vicinity of ten atmospheres, was measured by the reflectivity method in acetone, ethyl alcohol and ethyl ether. They are all of the order of 10^{-4}cm thick. Lower limits to the thickness were established in water, carbon tetrachloride, benzene and ethylene glycol. A theoretical expression for the thickness is derived. Comparison between theory and experiment suggests that the effective viscosity in the shock front is several times the ordinary shear viscosity in ethyl ether and acetone but agrees well in ethyl alcohol. A.

532.592

5917. The existence of solitary waves. K. O. FRIEDRICHS AND D. H. HYERS. *Commun. pure appl. Math.*, **7**, *No.* 3, 517–50 (*Aug.*, 1954).

A more direct proof than the one previously given by Lavrentiev (1947) of the existence of symmetric solitary waves of finite altitude is developed. The problem is first reduced to one in steady motion by adopting axes moving with the assumed velocity U of the wave. It is then described mathematically in terms of independent variables ϕ (the velocity potential) and ψ (the stream function) and dependent variables θ (the angle which the velocity makes with the horizontal and τ (the logarithm of the magnitude of the velocity), together with a parameter $\gamma = gh/U^2$, where h is the depth of the fluid at infinity. Simultaneous non-linear integral equations for θ and τ are set up which express the pressure condition on the free surface $\psi = 1$, together with an auxiliary integral condition representing the boundary condition at

infinity. It is then proved that, provided γ is less than but sufficiently near to 1, a non-trivial solution of the equations exist satisfying the required conditions.

A. T. PRICE

CAPILLARITY 532.6

532.61 : 530.162

5918. A statistical-mechanical theory of surface tension of curved surface layer. I. S. KONDO. *J. Phys. Soc. Japan*, **16**, *No.* 5, 381–6 (*May*, 1955).

Combined with a thermodynamical definition, an extension of Harasima's statistical-mechanical method to the calculation of plane surface tension leads to general expressions for the surface tension of the cylindrical and spherical interface. A new definition of "surface of tension" is introduced and the familiar Kelvin relation is derived more strictly by using this definition than by the traditional method. From the point of view of this definition Tolman's conclusion on the curvature dependency of surface tension turns out to be questionable and to need re-examination.

A.

532.612 : 536.655

5919. Surface tension and heat of vaporization of mercury, antimony, bismuth and arsenic. S. N. ZADUMKIN. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 2, 261–2 (1954) In Russian.

Calculation of the surface tension of these metals by means of a formula previously derived agrees with experimental data to within 10%. J. M. HOUGH

532.65

5920. Pulsation and mass transfer of pendent liquid droplets. F. H. GARNER, C. W. NUTT AND M. F. MOHTADI. Letter in *Nature* [*London*] **175**, 603–5 (*April* 2, 1955).

The pendent drops of nitrobenzene, chlorobenzene, carbon tetrachloride and chloroform contained acetone, ethyl alcohol, methyl alcohol and isopropyl alcohol as solutes. The pulsation and type of motion within the drops were found to depend on (*a*) rate of dropping, (*b*) concn. of the solute, and (*c*) the nature of the solvent. Small amounts of a surface-active compound suppressed the phenomena. W. GOOD

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

5921. Nuclear magnetic resonance in concentrated aqueous electrolytes. J. N. SHOOLERY AND B. J. ALDER. *J. chem. Phys.*, **23**, *No.* 5, 805–11 (*May*, 1955).

The proton magnetic resonance of water has been examined in the presence of various concentrations of different diamagnetic salts. The observed shifts of the resonance frequency relative to that of pure water are interpreted in terms of the breakdown of the hydrogen-bonded structure of water and the ability of the ions to polarize the water molecules. The concentration dependence of the shifts for the multivalent electrolytes indicates cation-anion interactions at higher concentrations. The quite narrow single line observed for all but the Al^{+++}, Be^{++} and the very concentrated $ZnCl_2$ solutions shows that in most cases the proton exchanges faster than 10^4 times per second. The magnetic field dependence of the line width in the $AlCl_3$ solution indicates that a rate of exchange of the proton of about 10^2 times per second is responsible for the broadening, while in the $ZnCl_2$ and $BeCl_2$ solutions the high viscosity appears mainly to be responsible for the increased line width. The fluorine magnetic resonance studied at several concentrations in KF solutions provides further information about the solvent-ion interaction. A.

532.7

5922. Proton relaxation in pure liquids and in liquids containing paramagnetic gases in solution. G. CHIAROTTI, G. CRISTIANI AND L. GIULOTTO. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 863–73 (*May*, 1955).

Some data on proton relaxation times in pure liquids completely free of oxygen in solution are reported. The observed values of T_1 are generally greater than those found by other authors. The value found for water agrees well with the value predicted by the theory of Purcell *et al.* The experimental values of T_1 for benzene, chlorobenzene and nitrobenzene seem to be somewhat longer than those given by Purcell's theory. The possible causes of the observed deviations (quasi-crystalline structure of liquids, microviscosity effect and molecular associations) are discussed. The influence of dissolved paramagnetic gases O_2 and NO is also studied. The magnetic moment of O_2 effective for the relaxation is of the same order of magnitude of the one derived from susceptibility measurements in the gas and is independent from the solvent. The μ_{eff} of NO on the contrary is considerably smaller than that resulting from susceptibility measurements and decreases with increasing polarity of the solvent. This behaviour of μ_{eff} of NO is attributed to interactions of the orbital magnetic moment with non-uniform local electric fields of the solvent. A.

532.7

5923. Theory of normal paraffin liquids. M. KURATA AND S. ISIDA. *J. chem. Phys.*, **23**, *No.* 6, 1126–31 (*June*, 1955).

A hole theory of *n*-paraffin liquids, which is the same in mathematical form as Flory's theory of polymer solutions, is developed to derive the relationships between the physical constants and the number of carbon atoms *n*. If the number of segments in a molecule is equal to $n^{\frac{2}{3}}$, quantitative agreements between the theory and the observations can be shown for the critical temperature, the critical pressure, the boiling temperature and the heat of vaporization. It is also possible to give theoretical foundations for some empirical rules recently proposed by Grunberg and Varshni. A.

532.72

5924. A direct determination of thermal-diffusion coefficients in liquids. H. KORSCHING. *Z. Naturforsch.*, **10a**, *No.* 3, 242–4 (1955) In German.

Description of a new method, which permits the

determination of thermal-diffusion coefficients by an optical deviation method. A number of organic substances are measured. H. C. COLE

532.72

5925. Thermal diffusion and molecular motion in liquids. E. L. DOUGHERTY, JR AND H. G. DRICKAMER. *J. phys. Chem.*, **59**, *No.* 5, 443–9 (*May*, 1955).

A theory for thermal diffusion in liquids has been developed which permits the prediction of the separation using only molecular weights, molar volumes, activation energies for viscous flow and excess thermodynamic properties. Measurements have been made on a series of binary mixtures of isomers with CS_2 at atmospheric pressure. These results and previously published results at high pressure are compared with the theory. There is excellent qualitative agreement, and in many cases the agreement is essentially quantitative. A.

532.73

5926. Virial coefficients of benzene–cyclohexane mixtures, and theories of liquid solutions. F. G. WAELBROECK. Letter in *J. chem. Phys.*, **23**, *No.* 4, 749–50 (*April*, 1955).

Accurate measurements on these substances enable a reduced 2nd virial coefficient to be plotted against a reduced temperature. The result suggests that $(2\varepsilon_{12}-\varepsilon_{11}-\varepsilon_{22})/\varepsilon_{11} = 0{\cdot}00 \pm 0{\cdot}02$. This differs from the value of 0·65 which would be obtained if the solution were conformal. R. O. DAVIES

532.739.2

5927. The effect of pressure on the solubility of solids in non-polar liquids. E. P. DOANE AND H. G. DRICKAMER. *J. phys. Chem.*, **59**, *No.* 5, 454–7 (*May*, 1955).

Solubility measurements under pressures to 10 000 atm have been made in the following systems: phenanthrene in CS_2, *n*-hexane, *n*-heptane, *n*-octane; SnI_4 in CS_2, *n*-hexane, *n*-heptane, *n*-octane; C_2Cl_6 in CS_2, *n*-hexane, *n*-heptane, *n*-octane, 2-methylpentane, 3-methylpentane, 2, 3-dimethylbutane, 2, 2-dimethylbutane; anthracene in CS_2. The results are analysed in terms of Scatchard–Hildebrand theory. In general, the effects of molecular structure assume greater importance at the higher pressures, especially for *n*-heptane. A.

532.74

5928. Linear association in nonaqueous solutions. R. GINELL AND J. SHURGAN. *J. chem. Phys.*, **23**, *No.* 5, 964–71 (*May*, 1955).

The two-constant theory of linear association has been considered further, and methods have been derived whereby the constants can be evaluated from experimental data. These methods have been applied to data on phenanthrene solutions in ethanol. The agreement of the derived curve with experimental points is excellent. The experimental data go up to ~3 molal solutions (~65 wt % soln). A.

532.74

5929. Spatial distribution of atoms in liquid He^4. L. GOLDSTEIN AND J. REEKIE. *Phys. Rev.*, **98**, *No.* 4, 857–70 (*May* 15, 1955).

The X-ray scattering diagrams of liquid helium, obtained by one of the authors, have been analysed in this paper using the Los Alamos "701" IBM Electronic Calculator. The liquid He^4 atomic correlation and pair distribution functions have thus been obtained over a wide range of interatomic separations and at a number of liquid temperatures between 1·25 and 4·20°K. The limitations in the experimental scattering structure factors give rise, among others, to two types of limitations in the correlation functions. One of these concerns their behaviour at small atomic separations; this limitation could be compensated for without difficulties. The second limitation, of more elusive character, appears to be connected with the lack in these functions of any manifest tendency toward their asymptotic behaviour at large atomic separations. The here derived correlation or pair distribution functions should nevertheless, be good approximations to their correct values at medium and intermediate separations extending to about 15 Å, whereby the relevant range extends to 10–15 Å. This could be verified using two types of integral checks on the correlation functions. In one of these, their space integrals, out to relevant distances, turned out to be quite close to their expected values determined only by the macroscopic properties of the liquid. In the second series of integral checks, they reproduced closely the original experimental structure factors. This verified the internal consistency of the calculations and indicated that the results should be correct at the relevant interatomic separations. At all the liquid temperatures here investigated, in any sphere of given radius, around an origin atom, or in any spherical shell of given thickness, the computed number of atoms was always less than what one would compute neglecting the interatomic correlations. An application, of major physical significance, of the correlation or pair distribution functions obtained in this work was made by deriving the approximate mean potential energies per liquid He^4 atom at the various temperatures. The mean potential energy, as a function of the liquid temperature, has a cusp at the λ-point. Its temperature derivative, which is the configurational heat capacity, is thus discontinuous at the transition point with an inverted λ-type of discontinuity. The knowledge of this qualitative behaviour of the configurational heat capacity was sufficient to prove, on quite general grounds, that the λ-transition of liquid He^4 is of kinetic energy origin, i.e. it is connected with the momentum space behaviour of the liquid atoms. A.

532.783

5930. Proton magnetic resonance in liquid crystals—orientation effects. P. L. JAIN, J. C. LEE AND R. D. SPENCE. *J. chem. Phys.*, **23**, *No.* 5, 878–82 (*May*, 1955).

Reports a study of the proton magnetic resonance signal from the liquid crystal phase of 4-4′ methoxyazoxybenzene, 4-4′ methoxy D_3 azoxybenzene and 4-4′ ethyoxyazoxybenzene in an effort to obtain information concerning the temperature dependence and relative extent of the molecular orientation in such phases. The experimental results lead to a qualitative picture of the distribution of molecular orientations for the first two compounds and show that the extent of orientation in the last compound is greater than in the first two. A.

MECHANICS OF GASES 533

533.15

5931. Interrelation of gaseous viscosity, self-diffusion, and isotopic thermal diffusion. E. M. HOLLERAN. *J. chem. Phys.*, **23**, *No.* 5, 847–53 (*May*, 1955).

The general interrelation of the theoretical first approximations to viscosity, self-diffusion and thermal diffusion previously derived is modified to conform with a simpler and more accurate approximation for the thermal diffusion ratio due to Kihara. The accuracy and limitations of this interrelation are discussed, with particular regard to the effect of considering higher approximations to the transport properties. With the recently published results for the modified Buckingham potential as a guide, the relation is further simplified, leading in particular to an approximate relation between viscosity and thermal diffusion which is shown to be in good agreement with the experimental data for argon. A.

533.16

5932. Automatic-reading viscosimeter. J. H. JUNKINS. *Rev. sci. Instrum.*, **26**, *No.* 5, 467–70 (*May*, 1955).

An automatic-reading capillary-type viscosimeter has been constructed for measuring the relative viscosities of gases. The measurement of the viscosity is made in terms of the time required for the pressure exerted by a charge of gas in the capillary forechamber to decrease from one fixed value to a second fixed value, while the gas flows through the capillary into a constant pressure vessel. Computation of the absolute viscosity is based on the following relationship between the time t for gas A whose viscosity n is known, and the time for gas B whose viscosity is being determined: $(t_{\text{gas }A})/(n_{\text{gas }A}) = (t_{\text{gas }B})/(n_{\text{gas }B})$. Pneumatic and electrical instruments are employed to (1) control the temperature of the bath in which the capillary is suspended, (2) maintain a constant pressure in the capillary exit vessel, and (3) actuate the timer which measures the interval corresponding to a given pressure drop in the capillary forechamber. The performance of these instruments is completely automatic, and primarily in this respect the apparatus described differs from manually-operated expiration-type capillary viscosimeters. Small groups of consecutive measurements (e.g. five runs on dry nitrogen at 65·0°C) yield readings which deviate from the mean value by the order of 7 parts in 10 000. A.

533.5 : 531.778.7 : 621.385.1

5933. Relation between gas pressure and ion current in vacuum tubes. S. MURATA. *J. Inst. Elect. Commun. Engrs Japan*, **37**, *No.* 12, 865–70 (*Dec.*, 1954) In Japanese.

A theoretical investigation of the ion-current method of measuring the pressure of high vacua is presented. Experimental work on sensitivity and residual-vacuum factor is also dealt with. In calculating sensitivity, the division of ions between the grid and cathode and the behaviour of ions produced in the cathode-grid region are taken into account. The introduction of a new quantity, termed the "average ionization efficiency," makes the calculations simpler than hitherto possible. Experimental results are given for water-cooled valves, the calculated and measured values of sensitivity agreeing well. The residual-vacuum factor lay between certain limits when the anode voltage was fixed. A simple formula is derived which is applicable both to planar and cylindrical electrode configurations. This formula, however, cannot be used when the cathode is not filamentary, nor when the equivalent-diode voltage is much higher than the ionization voltage of the gas.

A. WILKINSON (R)

533.5 : 621.38 : 666.1.037.5

5934. Shielded electrical connection into vacuum. G. A. HARROWER, F. S. BEST AND A. A. MACHALETT. Letter in *Rev. sci. Instrum.*, **26**, *No.* 4, 404–5 (*April*, 1955).

A coaxial seal of Kovar-to-Kovar sealing glass for bringing a shielded electrical lead through the glass envelope of evacuated apparatus is described and illustrated. It can be baked at 400°c and used at pressures of 5×10^{-10} mm Hg. The magnetic permeability and electrical resistance of Kovar make this coaxial lead unsuitable for some applications.

G. WITTENBERG

533.56

5935. The final vacua of oil diffusion pumps. R. F. COE. *J. sci. Instrum.*, **32**, *No.* 6, 207–13 (*June*, 1955).

Investigations have been made on the properties of several high quality diffusion pump oils. The improvement in final vacua obtainable by fractionating or purifying the oil within the particular pumps used is measured. A limit to this improvement is set by the oil independently of the mechanism by which it is achieved. Measurements of the vapour pressures of the oils by various methods are compared with final pressures measured with both ionization and Knudsen gauges. The residual molecules are vaporous and/or gaseous decomposition products of the oil, and vary with the type of oil. The average molecular weight of the products is substantially less than that of the oil.

A.

MOLECULAR THEORY OF GASES 533.7

533.7

5936. Direct evaluation of an integral occurring in the kinetic theory of gases. J. MOZER. *Annu. Fac. Phil. Skopje Sect. Sci. nat.*, **6**, *Paper* 2, 5 *pp.* (1953) In Serbo-Croatian with summary in German (50 words).

The mean relative speed for a pair of gas molecules in thermal equilibrium is calculated. R. EISENSCHITZ

533.7

5937. On the perfect gas and the equation of state of real gases. Y. MORI. *J. Sci. Res. Inst.* [*Tokyo*] **48**, 272–9 (*Dec.*, 1954).

The perfect gas is proved to be defined as the gas of zero molecular radius by theoretical and experimental analyses. Properties of real gases at zero pressure are shown not always to coincide with those of the perfect gas except with reference to the equation of state and the relations between real gases and the perfect gas are discussed. An empirical equation of state of a real gas is reasonably shown to have to be of the virial expansion type. A.

533.7

5938. Theory of gases. XXI. J. Duclaux. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 14, 1497–9 (*April* 4, 1955) In French.

For Pt XX, see Abstr. 8979 (1954). The author's theory of progressive condensation [Abstr. 8564 (1950)] is used to calculate the coefficients K_n in the "law of mass action" $C_1C_n = K_nC_{n+1}$, where C_n is the concentration of assemblies of n associated molecules. The results are in excellent agreement with experiment. E. H. SONDHEIMER

533.7 : 539.13

5939. Exp : six potential and properties of gases. M. P. Madan. Letter in *J. chem. Phys.*, **23,** *No.* 4, 763–4 (*April*, 1955).

The force constants in the exp : six potential [Abstr. 4266 (1954)] are evaluated for argon and methane from thermal diffusion data, and are in good agreement with other estimates. The coefficient of self-diffusion calculated from these force constants agrees well with experimental values [Abstr. 2455 (1951)]. E. H. SONDHEIMER

533.7 : 536.42

5940. On first-order phase transitions in canonical and grand ensembles. T. L. Hill. *J. chem. Phys.*, **23,** *No.* 5, 812–16 (*May*, 1955).

S. Katsura has found evidence from exact calculations on finite systems that has led him to suggest that, contrary to the generally accepted view, a van der Waals type loop will be found in an exact application of the canonical ensemble to a first-order phase transition. It is shown here that Katsura's results can be understood in terms of interfacial free energy in the two-phase region. A loop is indeed obtained, but it is not of the van der Waals type. In particular, the loop vanishes in the limit of an infinite system. The well-known argument of van Hove showing that a loop does not exist in an infinite system (canonical ensemble) is discussed in this connection. A.

533.73

5941. Second virial coefficients of vapour mixtures. P. G. Francis and M. L. McGlashan. *Trans Faraday Soc.*, **51,** *Pt* 5, 593–9 (*May*, 1955).

The second virial coefficients of the pure substances carbon tetrachloride and chloroform and of the mixtures carbon tetrachloride + chloroform and benzene + chloroform have been determined. The results for pure substances are compared with those of previous workers. They are also shown to obey a principle of corresponding states fairly well. The results for mixtures have been analysed in terms of the treatment of Lewis and Randall and also in terms of the treatment of Guggenheim and McGlashan based on the principle of corresponding states. It is found that for the particular mixtures studied there is little to choose between these two treatments, each of which gives a satisfactory fit of the experimental results. A.

VIBRATIONS . ACOUSTICS 534

534.112

5942. Effect of air damping on transverse vibrations of stretched filaments. D. W. Stauff and D. J. Montgomery. *J. appl. Phys.*, **26,** *No.* 5, 540–4 (*May*, 1955).

The effect of air damping on the resonant frequencies of forced vibration of stretched filaments is studied by observing the shift in frequency when the surrounding medium is changed from air at atmospheric pressure to hydrogen at the same pressure, or to air at reduced pressures. For fibres of linear density less than about 10 μg/cm, the shift between atmospheric air and vacuum exceeds 1 c/s, becoming greater as the fibres become finer. The frequency shifts observed experimentally are compared with those predicted by certain formulae of Stokes. It is found that the theory works well enough to allow the effect of air damping to be taken into account in measurements of linear density by means of the vibroscope. However, the observed shift seems to be 1–2 c/s higher than that calculated in the case of small shifts, and about 20 or 30% higher in the case of large shifts. A rigorous evaluation of the applicability of Stokes's theory would require further investigation. A.

534.113

5943. On the correction to the elementary calculation of the eigenfrequency of the vibrations of a cylindrical rod. H. Wittke. *Z. angew. Phys.*, **7,** *No.* 3, 148–9 (*March*, 1955) In German.

It is shown that a well-known but very cumbersome correction to the elementary calculation is given to a good degree of approximation by a simple expression, and this is plotted nomographically for various E/G ratios, length to diameter ratios, and for the fundamental and first overtones. The expression is less accurate for higher overtones; for example, on the fifth overtone, when the correction should be 8·997%, it is given as 9·026% W. M. LOMER

534.13

5944. Longitudinal and screw vibrations of beams. G. J. Kynch. Letter in *Nature* [*London*] **175,** 559 (*March* 26, 1955).

Exact calculations have verified the existence of two sets of "screw vibrations" which in beams of rectangular or elliptical cross-section may interfere with the longitudinal and torsional vibrations.

W. BARDSLEY

534.2

5945. Wave propagation in even and odd dimensional spaces. N. L. Balazs. *Proc. Phys. Soc.* [*London*] *A*, **68,** *Pt* 6, 521–4 (*June*, 1955).

It is shown how the evenness and oddness of the spatial dimensions influence the general properties of wave propagation. The solution of the inhomogeneous wave-equation will be given by a multiple integral; one of the integrations is to be performed in a complex time-plane. The singularities of the integrand in this plane have an alternating character depending on the evenness or oddness of the spatial dimensions. If the space is odd-dimensional, the singularities are poles; if it is even-dimensional, the singularities are branch points. This, then, will alter profoundly the properties of the solution. A.

534.21 : 537.525

5946. On electro-acoustic waves in gas discharge plasma. M. V. KONYUKOV AND YA. P. TERLETSKIĬ. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11) 542–8 (1954) In Russian.

A theoretical paper discussing the way in which the movements and collisions of ions, electrons and neutral particles produce acoustic waves. There are two types of wave, one due to ions and one to electrons; the electron waves are more rapidly attenuated.

J. M. HOUGH

534.213 : 548.0

5947. Specific directions of longitudinal wave propagation in anisotropic media. F. E. BORGNIS. *Phys. Rev.*, **98**, *No.* 4, 1000–5 (*May* 15, 1955).

Plane elastic waves can be propagated in every direction of an unbounded elastic medium. It is known that associated with each direction there are three independent waves, the displacements of which form a mutually orthogonal set. In general none of the three displacement vectors coincides with the vector of the normal to the wave front, that is, in general the waves are neither longitudinal nor transverse. The purpose of this paper is to find specific directions in a medium of given anisotropy, along which the displacement of one of the three possible waves is exactly parallel to the direction of wave propagation. A method is developed which leads to the complete set of such "longitudinal" directions, if the matrix of the elastic coefficients is known. The method is applied to several groups of crystal symmetry, namely to the trigonal, hexagonal, tetragonal and cubic systems, and the general conditions are established under which pure longitudinal waves exist. For α-quartz, for example, the numerical calculation shows that there are five such distinct directions, not counting the ones which are equivalent by symmetry properties. As a by-product of the results, special conditions between the elastic constants are obtained under which longitudinal waves could be propagated in any direction in a hypothetical anisotropic medium fulfilling these conditions. Owing to their relation to an early investigation by G. Green in 1839, the latter are called specialized Green's conditions. A.

534.22/.23

5948. The laws for the excess absorption and the dispersion of sound in $MgSO_4$ solutions at frequencies above 3 Mc/s. N. S. TAŞKÖPRÜLÜ. *Rev. Fac. Sci. Univ. Istanbul C*, **19**, *No.* 2, 110–14 (*April*, 1954).

The measurements of the absorption of ultrasound in $MgSO_4$ solutions made by Smith *et al.* (1951) at frequencies higher than 3 Mc/s have been analysed. It is concluded that the excess absorption observed in this region can be explained by the relaxation theory if the relaxation frequency ν_r and the maximal relative dispersion $D_0 = (v_\infty - v_0)/v_0$ are given by the following expressions: $\nu_r = 50 \cdot 6c^{1/2}$ Mc/s, $D_0 = 21 \cdot 5 \times 10^{-4} c^{1 \cdot 2}$, where c is the concentration, v_0 and v_∞ the velocities of sound on the higher and lower side of the region of relaxation. These values allow the calculation of a relative dispersion $D = (v_{15} - v_5)/v_5 = 0 \cdot 16 \times 10^{-3}$ for a 1 mol/litre $MgSO_4$ solution at 5 and 15 Mc/s. This value agrees nearly, within the limit of error, with the observed dispersion. A.

534.22

5949. A contribution to the measurement of sound dispersion in liquids. G. SCHMID AND W. SCHMIDT. Note in *Naturwissenschaften*, **42**, *No.* 5, 123 (1955) In German.

It is suggested that the method of Fox and Marion [Abstr. 5914 (1953)] can be improved by enclosing the liquid being examined in a vessel (whose walls are transparent) which is itself surrounded by a non-dispersing liquid. The transmitting crystal is immersed in this outer liquid and is at a fixed distance from the receiver which is enclosed in the movable vessel. T. C. TOYE

534.22 : 532.122

5950. Ultrasonic velocity and adiabatic compressibility in mixtures of alcohols and polyalcohols. F. DANUSSO. *R.C. Accad. Naz. Lincei*, **17**, *No.* 6, 370–5 (*Dec.*, 1954) In Italian.

The percentage deviations from corresponding values for ideal mixtures, of molecular volume, ultrasonic velocity and adiabatic compressibility, with varying concentration at 30°C, for binary mixtures of alcohols, polyalcohols and water with glycerine as the common component, are tabulated and graphed. Their general behaviour resembles that for corresponding mixtures using glycol [see Abstr. 4450 (1955)]. They are greater with glycerine. Comparison of mixtures of water or methanol with glycol or glycerine indicates that water plus polyalcohol systems differ from alcohol plus polyalcohol systems due to structural differences. In the former the positions of volume and velocity deviation maxima are equally sensitive to equifunction proportions of the components. In the latter, those for velocity are more sensitive to equimolecular proportions. J. J. PHIPPS

534.22 : 533.7

5951. Energy transfer by collisions in vapors of chlorinated methanes. D. SETTE, A. BUSALA AND J. C. HUBBARD. *J. chem. Phys.*, **23**, *No.* 5, 787–93 (*May*, 1955).

Ultrasonic velocity has been measured at 30°C in the four chlorinated methanes: methyl chloride, methylene chloride, chloroform and carbon tetrachloride, at pressures from 1·5 cm Hg to more than one atm in the case of methyl chloride, and with the others to the vapour pressures available up to 28°C and at frequencies from 0·2 to 2 Mc/s. Dispersion of the velocity has been found in each case, the relaxation frequency/pressure ratios, correcting for departure from the ideal gas law, at 30° being in CH_3Cl, $CHCl_3$ and CCl_4, respectively, 1·13, 27·3 and 23·3 Mc/s atm^{-1}. In CH_2Cl_2 two relaxations have been found with respective frequency/pressure ratios after similar corrections of 2·27 and 105 Mc/s atm^{-1}. A.

534.222.2

5952. Propagation of shock waves in aluminium. H. D. MALLORY. *J. appl. Phys.*, **26**, *No.* 5, 555–9 (*May*, 1955).

The velocity of shock waves in aluminium and the associated translational motions, produced by metal-metal impact, have been determined by an electrical contact technique. The results obtained have been used to evaluate an equation of state for the metal. A.

534.222.2

5953. Asymptotic spherical shock decay. L. M. TANNENWALD. *J. appl. Phys.*, **26**, *No.* 5, 551–5 (*May*, 1955).

It is shown that the description of viscous and heat conductive effects in asymptotic spherical shock decay can be reduced to the solution of an ordinary first-order differential equation relating shock strength and radius. The derivation of this equation is based, to a considerable extent, on a well-justified quasi-stationary approximation. Computational work required for handling specific situations is outlined.

A.

534.222.2 : 533.6.011.4

5954. On the acoustics of supersonic motion. P. BLOCH-DASSAULT. *C.R. Acad. Sci.* [*Paris*] **237**, *No.* 19, 1123–6 (*Nov.* 9, 1953) In French.

Discusses the origin and nature of the detonations produced by aircraft at supersonic speeds, referring particularly to the occurrence of double supersonic bang. The possibility that these two shock waves have their origin in different parts of the aeroplane is excluded as it does not agree with observation. The explanation developed in the present paper derives from the classical work of Esclangon [*Acoustiques des canons et des projectiles* (1925), and *C.R. Acad. Sci.* [*Paris*] **237**, 361 (1953)] which discusses supersonic flight of projectiles, and is now applied to supersonic flight of aircraft. The two sound pulses arise (1) from the spherically spreading sound wave with normal velocity of sound, and (2) from the conical pressure surface spreading from the nose of the aircraft with a velocity depending on the Mach number. The time interval between arrival of the two pressure waves at an observer on the ground will depend on the relative positions, etc., of the observer and the aircraft.

A. B. WOOD

534.23

5955. Sound transmission, reflection and absorption through gratings and porous materials. W. REICHARDT. *Hochfrequenztech. u. ElektAkust.*, **63**, *No.* 6, 145–53 (*Feb.*, 1955) In German.

After referring to Rayleigh's theory of sound transmission through and absorption by a porous wall, the author develops a theory which uses as a basis the analogy existing between oscillating electrical and mechanical systems. Using a combination of inductances, capacitances and resistances, electrical circuits are given equivalent to the various mechanical systems such as acoustic gratings and porous walls. The latter are assumed to consist of regularly spaced cavities of prescribed dimensions which are mathematically amenable to such treatment. An interesting case is that of a sound absorber for use under water—consisting of a rubber sheet, with a regular pattern of holes punched in it, sandwiched between a continuous sheet of rubber and a sheet of metal. The cases considered for the sandwich are (*a*) metal air-backed, (*b*) metal water-backed and (*c*) punched rubber sheet water-backed. Reference is made to work by E. Meyer and H. Oberst on "A resonance absorber for water-borne sound" [Abstr. 2190 (1954)] which used this principle in a material known as "Alberich" for making a submarine non-reflecting to incident sound.

A. B. WOOD

534.23

5956. Ultrasonic absorption in sugar solutions. G. S. VERMA. *J. chem. Phys.*, **23**, *No.* 5, 876–7 (*May*, 1955).

Ultrasonic absorption and the frequency at which maximum absorption is to be expected have been calculated in solutions of sucrose, glucose and lactose at various concentrations and temperatures on the basis of structural changes in the quasi-crystalline structure of the liquid medium. The relaxation frequencies for sugar solutions lie just beyond the ordinary experimental range (~100 Mc/s).

A.

534.23 : 532.74

5957. Structural effects in the ultrasonic absorption of liquid mixtures. D. SETTE. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 800–21 (*May*, 1955).

Experiments have been performed to clarify the behaviour of those binary liquid mixtures where the ultrasonic absorption coefficient has a maximum at an intermediate concentration. Measurements on water-methyl alcohol mixtures at −10 and −32°c have shown that a maximum of the absorption coefficient is present just as in the other water-alcohol systems. This corroborates Storey's theory that the losses are caused by relaxation phenomena due to alteration of the molecular association equilibrium produced by temperature variations. Research on mixtures of partially soluble liquids in the critical region permits an approximate calculation of the increase of viscosity losses produced by the density fluctuations in the liquid. This calculation shows that while the viscosity losses can be much greater than those given by Stokes's formula, they are not sufficient to explain the values of the experimental absorption coefficient. The relaxation phenomena in the equilibrium among mother phase and clusters are the more important dissipative effects. The conclusion is reached that in all these mixtures having a maximum of the absorption coefficient, the losses are caused primarily by relaxation phenomena due to the variation of the equilibrium among different ways in which molecules of the two kinds can associate. The equilibrium is altered by the temperature variations produced by sound waves.

A.

534.614

5958. On a method for determining the velocity of ultrasound in liquid and solid substances in a wide temperature range. A. K. SCHULZ. *Z. angew. Phys.*, **7**, *No.* 3, 144–8 (1955) In German.

The method involves the application of short duration pulses to a quartz crystal; after traversing the substance being examined the wave is reflected from a reflector placed opposite the quartz. The echoes thus produced by successive reflections are received by the crystal on their return and reconverted into electrical impulses which are registered on a c.r.t. as a series of peaks. Measurement of their positions gives a value of the velocity while their respective heights display the effect of absorption. Glycerine has been examined between −130 and +130°C.

T. C. TOYE

534.7

Physiological acoustics. Hearing. *See also under* "Medical science. Human physiology." Decimal classification 612.85

534.76

5959. A contribution to the theory of binaural hearing. O. SCHÄFER AND H. SCHLITT. *Z. angew. Phys.*, **7**, *No.* 4, 165–8 (1955) In German.

Attention is drawn to the differences which exist in listening to speech and music with the "unaided" ears and in listening via a transmission system (telephone or radio). The "apparent" reverberation is different according to whether listening is nonaural or binaural. Experiments are described in which a pair of receiving cones are connected in stethoscope-fashion to either one or both ears of the observer, and also when they are connected to a condenser microphone and transmitted to the ears over a "line." In these experiments the frequencies are varied over a range 700–2 500 c/s which can be sent out in the form of pulses, and the spacing between the two pick-up cones can be varied. As a result of these experiments, it is concluded that the observed effects are essentially of a physical nature and have a bearing on existing theories of binaural hearing. A. B. WOOD

OPTICS . RADIATION . SPECTRA 535

535.14

5960. General results concerning the description of a photon in a material medium. A. BATTIG. *Rev. Univ. Tucumán A*, **10**, *No.* 1–2, 111–35 (*Nov.*, 1954) In Spanish.

An attempt is made to represent the photon as a particle of non-zero rest mass, the total energy of the particle being the ordinary relativistic energy plus a potential representing the action of the medium.

R. A. NEWING

535.23.08

5961. The measurement of very small radiation intensities with thermopiles. F. HOFFMANN AND U. SCHLEY. *Z. angew. Phys.*, **7**, *No.* 3, 109–13 (1955) In German.

The output from a thermocouple is fed into a galvanometer of high sensitivity. Light is reflected by the mirror of this primary galvanometer on to a differential thermopile connected to a secondary galvanometer. The electrical and optical sections are considered in detail and the sensitivity is estimated. It is claimed that intensities of the order of 5×10^{-11} W can be measured. E. H. DOCK

535.231.2

5962. A note on black body radiation. A. M. CROOKER AND W. L. ROSS. *Canad. J. Phys.*, **33**, *No.* 5, 257–60 (*May*, 1955).

A paper by Czerny [*Ergebnisse der exakten Naturwissenschaften*, **17**, 70–107 (1938)] is discussed, and one of his suggestions is applied and extended. This relates to the Planck formula for the radiation.

L. S. GODDARD

535.241.431

5963. Interreflections in rooms by a network method. P. F. O'BRIEN. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 419–24 (*June*, 1955).

A network method for the prediction of the luminous-emittance distribution after inter-reflections in rooms with specified geometry, initial division of light flux to the room surfaces and luminous reflectances of the room surfaces is presented. Potentials in the network are initial and total (i.e. after interreflections) luminous emittances while the surface reflectances and shape factors define the resistances. Uniform illumination of all surfaces and diffuse light-flux emission and reflection are postulated. Algebraic solutions to the networks describing infinite and cubical rooms are presented. The average illumination of any plane of arbitrary orientation, such as the working plane, can be computed by a floating potential node technique. Luminous-emittance distributions in a cubical room as obtained by Moon's integral-equation solutions are compared with data obtained by the network method. A.

535.245.22 : 535.39

5964. Theory of the integrating sphere. J. A. JACQUEZ AND H. F. KUPPENHEIM. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 460–70 (*June*, 1955).

The general theory of the integrating sphere as used in the measurement of total spectral reflectance is formulated as an integral equation and solved for five special cases. Two methods of measuring reflectance are considered. In the substitution method, sample and standard are placed in turn at the sample aperture and the ratio of the respective photocell readings determined. In the comparison method, both sample and standard are in place at all times at their respective apertures. The beam is switched from sample to standard and the ratio of the respective photocell readings determined. The efficiency and error, and their interdependence are discussed for both methods and for different geometries of the sphere. The design of a comparison-type sphere with maximum efficiency and low error is considered. A.

535.247

5965. Ratio measuring twin-beam photometer. M. J. E. GOLAY. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 430–3 (*June*, 1955).

A spectrophotometric system is described in which the percentage transmission or reflection of a sample is obtained as a directly recordable d.c. output. A.

535.247.4 : 545.823

New fluorescence photometer. *See Abstr.* 6593

535.31

5966. Kinetic treatment of optical problems. A. REUSCHEL. *Optik*, **12**, *No.* 3, 128–35 (1955) In German.

Deals with the fundamental theory of the connection between kinematics and certain optical problems, beginning with a design for a mechanism for solving $n \sin \epsilon = n' \sin \epsilon'$, given any three of the quantities in the equation. The same principle can be extended to a series of refractions. Possible applications include ray tracing across aspherical surfaces and through media of constantly changing refractive index.

N. CORCORAN

535.317

5967. Optical tolerances. F. I. HAVLIČEK. *Optik*, **12**, *No.* 3, 123–7 (1955) In German.

A semi-graphical method is used to determine the axial illumination and contrast in the image formed by a lens suffering from spherical aberration. The

method is applied to a plano-convex lens and to a photographic objective. The optimum aperture of the lens and its depth of focus can be deduced.

R. W. FISH

535.317.25

5968. Photographic resolving power and aberrations of lenses. N. MURCOTT AND H. T. GOTTFRIED. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 434–40 (*June*, 1955).

The performance and aberrations of three aircraft camera lenses, all of about 20 in. focal length and $f/6{\cdot}3$ aperture were measured. The performance was assessed in terms of low-contrast photographic resolving power, and the wave front and transverse ray aberrations were determined interferometrically. The interferometer used was a variation of the Twyman and Green instrument, in which the plane of focus for resolving power test and the centre of curvature of the reference sphere for interferometry were directly relatable. A.

535.317.5

5969. Automatic correction of third-order aberrations. R. E. HOPKINS, C. A. MCCARTHY AND R. WALTERS. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 363–5 (*May*, 1955).

A method for the automatic correction of third-order aberrations in thick lenses has been tried on several lens problems. The procedure is to use the Newton method for solving the non-linear equations involved. The derivatives are found by differentiating the third-order surface contribution formulae. The method has proved to be successful on a large variety of lens types. A.

535.317.9 : 539.234

5970. Optical aspherizing by vacuum evaporation. J. A. DOBROWOLSKI AND W. WEINSTEIN. Letter in *Nature* [*London*] **175**, 646–7 (*April* 9, 1955).

The use of zinc sulphide films, giving retardations of 30–40λ mercury green light, is described. The films were stable and showed no signs of weathering. A few practical details are given, together with figures for the accuracy obtained. R. W. FISH

535.318

5971. A Petzval objective of great light grasp for miniature film projection. A. WERFELI. *Optik*, **12**, *No.* 3, 117 (1955) In German.

Constructional data for an $f/1{\cdot}4$ projection lens are given. This lens consists of four uncemented elements and is said to have very little curvature of field. R. W. FISH

535.318

5972. Catadioptric system for the recording of feeble intensities, and for the exploration of the near infrared. A. BAYLE. *Rev. Opt.*, **34**, *No.* 3, 163–8 (*March*, 1955) In French.

Correcting elements for a spherical mirror objective have either been difficult to manufacture, as the Schmidt plate, or suffer from residual aberrations as in the mensicus correctors of Maksutov or Bouwers. A meniscus corrector having one spherical surface, the other paraboloidal is described which overcomes both difficulties. Some details of systems ranging from 25 mm to 450 mm in focal length, and from $f/0{\cdot}65$ to $f/1{\cdot}0$ are given. R. W. FISH

535.321

5973. Review of the principal methods for the measurement of refractive indices. J. LECOMTE. *Rev. Opt.*, **34**, *No.* 3, 150–63 (*March*, 1955) In French.

A review of methods available for the determination of refractive indices of solids, liquids and gases in the infrared region. Some results are quoted and difficulties encountered in practical work are discussed.

R. W. FISH

535.33.03 : 535.339

5974. Measurement of stray light in a monochromator. B. S. PRITCHARD. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 356–60 (*May*, 1955).

In spectrophotometry and spectroradiometry photometric errors due to stray light passed by the monochromator employed are always present to some degree. The magnitude of the errors is dependent upon the spectral distribution of the energy entering the monochromator, the stray light characteristics of the monochromator, the effects of any filters or to components between the monochromator and the phototube and the spectral response of the phototube or other receptor. Means are outlined of measuring the stray-light characteristics of a monochromator and expressing the results in the form of a table or grid of numbers. From the grid values it is a relatively simple process to estimate closely the photometric errors in any given application. Finally, various means are suggested of reducing the effects of stray-light errors. A.

535.33.07

5975. Small grating spectrometer for the far infrared region. E. K. PLYLER AND N. ACQUISTA. Letter in *J. chem. Phys.*, **23**, *No.* 4, 752–3 (*April*, 1955).

Curves of water vapour absorption are shown for λ up to 100μ. G. F. LOTHIAN

535.33.07

5976. Invariance of integrated transmittance and total fractional transmission with experimental slit function. C. R. DEPRIMA AND S. S. PENNER. Letter in *J. chem. Phys.*, **23**, *No.* 4, 757–8 (*April*, 1955).

A mathematical consideration of the conditions necessary for this invariance to obtain. G. F. LOTHIAN

535.33.07

5977. Mirror condenser for spectrographs. S. ROSIN. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 5, 398 (*May*, 1955).

A system related to the "Axicon" described in Abstr. 9036 (1954). G. F. LOTHIAN

535.33.07

5978. Interferometric method of measuring the spectral slit width of spectrometers. V. J. COATES AND H. HAUSDORFF. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 425–30 (*June*, 1955).

The spectral slit width of a monochromator is defined as the half-intensity band widths of frequencies passed by the exit slit. This paper discusses its measurement using methods similar to those used to measure the frequency transmission of electrical networks. A Fabry–Pérot interferometer, used as a sinusoidal signal generator, produces interference fringes constantly spaced in wave-numbers at a known amplitude input to the monochromator. It can be

shown that the attenuation of the fringe pattern as the spacing is changed is a function of the exit-slit output-intensity distribution function. From this information the spectral slit width in any spectral region can be measured and the exit-slit function indicated. The sensitivity of measurement is limited by the fringe amplitude obtainable from the interferometer, which is a function of the reflectivity of the interferometer plates and their adjustment. Rays passing through the interferometer at other than normal incidence tend also to damp the fringe pattern. A.

535.331

5979. A study of C III by means of a sliding vacuum spark. K. BOCKASTEN. *Ark. Fys.*, **9**, *Paper* 30, 457–81 (1955).

A light source has been devised, using a sliding spark in vacuum, which gives an intense spark spectrum of carbon with small Stark effect perturbations. It has been applied to a study of C III in the region 9950–1900 Å. A total of 192 lines has been measured, 121 of which had not been observed before, and the analysis has given 21 new levels. The singlets and triplets have been connected, and the ionization limit has been accurately determined from the ng^3G-series. Some C III lines and the resonance lines of C IV in the vacuum region have been measured on old plates taken by Edlén. The whole term system has been recalculated on the basis of the new data. The original purpose of the investigation was to get the wavelength data needed for the interpretation of stellar spectra. As recently shown by Edlén (1954), the new C III data have essentially explained the infrared emission bands in the Wolf–Rayet stars of the carbon sequence. A.

535.331

5980. Relative *gf*-values for lines of Co I. R. B. KING, B. R. PARNES, M. H. DAVIS AND K. H. OLSEN. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 350–3 (*May*, 1955).

The relative *gf*-values of 256 lines in 58 multiplets in the spectrum of Co I have been measured in electric furnace absorption spectra. The lines lie in the wavelength range 2987–6450 Å and arise from low terms whose excitation potentials are between 0·00 and 3·24 eV. A.

535.331

5981. The spectrum of singly-ionized magnesium, Mg II. P. RISBERG. *Ark. Fys.*, **9**, *Paper* 31, 483–94 (1955).

The spectrum of singly-ionized magnesium has been observed between 11620 and 2790 Å with a hollow-cathode discharge. Wavelengths have been determined for 93 lines, 26 of which fall above 7896 Å, the upper limit of previous observations. The term system has been revised and extended, and series formulae have been computed. Wavelengths in the vacuum-ultraviolet have been calculated for use as standard wavelengths. A.

535.331

5982. Hyperfine structure of the spectrum of Mn I. K. MURAKAWA. *J. Phys. Soc. Japan*, **16**, *No.* 5, 336–8 (*May*, 1955).

The hyperfine structure of the lines Mn I λ5432, λ5395 and λ4034 was measured, and the quadrupole moment of Mn^{55} was calculated to be $(0{\cdot}4 \pm 0{\cdot}2) \times 10^{-24}\,cm^2$. A.

535.331

5983. Description of the tertiary spectrum of nickel (Ni III) between 2300 and 9000 Å. O. GARCÍA-RIQUELME AND R. VELASCO. *An. Real Soc. Españ. Fis. Quim.*, **51(A)** *No.* 1–2, 41–58 (*Jan.–Feb.*, 1955) In Spanish.

For purposes of astrophysical line identification and of structural analysis, the Ni^{++} spectrum was excited by using a Ni tube as hollow cathode and producing a condensed discharge in it at about 750 V, with He as filling gas in the system. The spectrum was photographed with the aid of a quartz prism spectrograph and a concave grating spectrograph in Wadsworth mounting. The wavelengths were estimated using as standards Ni I, Ni II, Fe II, Ne I and He I lines. Estimated relative intensities are also given ranging from 1 to 2000. The measurements were made from 2300 to 9000 Å for more than 2000 lines. Wavelengths are presented to three decimal places when the probable error is less than 0·007 Å. In the other cases this error is less than 0·02 Å. The authors are using these data to analyse Ni III. A.

535.331

5984. New lines classified in the spectrum of Ni III. O. GARCÍA-RIQUELME AND R. VELASCO. *An. Real Soc. Españ. Fis. Quim.*, **51(A)** *No.* 1–2, 59–66 (*Jan.–Feb.*, 1955) In Spanish.

Using Shenstone's atomic levels of Ni^{++}, 168 new Ni III lines have been classified in the region 2300–9000 Å, recently measured by the authors. These results confirm the previous levels and support the wavelength values published. A.

535.331

5985. New lines in the spectrum of neutral titanium (Ti I). A. K. WARDAKEE. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 354–5 (*May*, 1955).

One hundred and thirteen new lines of Ti I, in the region ordinarily masked by the α-bands of TiO, have been measured in the spectrum of the electrodeless-discharge lamp recently described in this journal by Corliss, Bozman and Westfall. A.

535.333

5986. The visible emission spectrum of Br_2^+. P. B. V. HARANATH AND P. TIRUVENGANNA RAO. Letter in *Curr. Sci.*, **24**, *No.* 3, 79–80 (*March*, 1955).

A new vibrational analysis of the bands first observed by Uchida and Ota [*Japan J. Physics*, **5**, 59 (1928)] is proposed. The constants (cm^{-1}) are:

ν_e	ω_e	$x_e\omega_e$
19290	190	1·0
18782	152	0·35
0	376	1·25

R. F. BARROW

535.333

5987. Infrared spectrum of hydrogen and deuterium between one and two microns. S. P. S. PORTO AND G. H. DIEKE. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 447–50 (*June*, 1955).

More than 2600 new lines have been measured in the emission spectra of H_2 and D_2 between 1·15 and 1·97 μ, with lead sulphide cells and powerful discharge

tubes. Most of the strong lines below 1·65 μ belong to known band systems. Beyond this, new and so far incompletely analysed band systems become prominent. A.

535.333 : 551.593.9

5988. Production of excited hydroxyl radicals in the hydrogen atom-ozone reaction. J. D. McKinley, Jr, D. Garvin and M. J. Boudart. *J. chem. Phys.*, **23**, *No.* 5, 784–6 (*May*, 1955).

Near-infrared emission spectrograms of vibrationally excited hydroxyl radicals in the ground state have been obtained upon mixing H atoms and ozone. A recent interpretation of a particular source of the night-sky radiation has been verified. A non-equilibrium distribution of energy between the reaction products is indicated. A.

535.333

5989. The band spectrum of tellurium in the visible. N. D. Prasad and P. Tiruvenganna Rao. *Indian J. Phys.*, **28**, *No.* 12, 549–62 (*Dec.*, 1954).

The band spectrum of tellurium in the visible region was reinvestigated. The well-resolved fluctuation bands, analysed by Desirant and Minne (1936) into two separate systems have been found to belong to the principal system. The following vibrational constants were derived for the principal system:

$$\omega_e'' = 251{\cdot}0 \qquad x_e''\omega_e'' = 0{\cdot}56$$
$$\nu_e = 22\,709$$
$$\omega_e' = 163{\cdot}0 \qquad x_e'\omega_e' = 0{\cdot}96$$

The analysis is confirmed from considerations of isotope effect. A.

535.333

5990. Fermi resonance in the emission spectrum of benzene. S. Leach. *J. Chim. phys.*, **52**, *No.* 1, 12–23 (*Jan.*, 1955) In French.

The results of a detailed study of the effects of Fermi resonance on the emission spectrum of benzene vapour in the near ultraviolet are discussed and compared with the previously-recorded analyses of Garforth and Ingold (*J. Chem. Soc.*, **1948**, 427) on the fluorescence spectrum, and of d'Asundi and Padhye [Abstr. 142, 2333 (1950)] on the emission spectrum. G. I. W. Llewelyn

535.337

5991. The Stark effect of symmetric top molecules at high field strengths. C. Schlier. *Z. Phys.*, **141**, *No.* 1–2, 16–18 (1955) In German.

The general solution of the Schrödinger wave equation for the Stark effect for rigid symmetric tops is given in continued fraction form. The results are given graphically for $J = 1, 2$ and $K, M \neq 0$.

D. H. Whiffen

535.337

5992. Zeeman effect in the rotational spectrum of NO. M. Mizushima, J. T. Cox and W. Gordy. *Phys. Rev.*, **98**, *No.* 4, 1034–8 (*May* 15, 1955).

The Zeeman splitting of the 2 mm wave, $J = 1/2 \rightarrow 3/2$ rotational transition of $N^{14}O^{16}$ in the $^2\Pi_{1/2}$ electronic state has been measured with fields of the order of 100 gauss. The observations were made with a waveguide cell coiled between the poles of a Varian magnet. Magnetic field measurements were made with the electronic resonance of DPPH at frequencies of the order of 300 Mc/s. A general theory of the Zeeman effect with h.f.s. has been developed and applied specifically to $N^{14}O^{16}$. The g factors for the four states under investigation were found theoretically to be expressed as: $J = 1/2$, $g_c = 0{\cdot}0007 - \alpha$, $g_d = 0{\cdot}0007 + \alpha$; $J = 3/2$, $g_c = \bar{g} - \frac{1}{3}\alpha$, $g_d = \bar{g} + \frac{1}{3}\alpha$, where c and d are the lower and upper components of the Λ-type doublet, respectively. This relation was found to hold experimentally well with the values, $\bar{g} = -0{\cdot}0230$ and $\alpha = +0{\cdot}0025$. Theoretically, $\bar{g}$ comes from the mixing of $^2\Pi_{1/2}$ and $^2\Pi_{3/2}$ states and α comes from that of $^2\Pi_{1/2}$ and $^2\Sigma$ states. It was found by the theory, in which the centrifugal force and the spin orbit coupling were taken into account, that the electronic wave-function of the two rotational states should be: $J = 1/2$, $(^2\Pi_{1/2}| - 0{\cdot}0021(^2\Sigma|$; $J = 3/2$, $(^2\Pi_{1/2}| - 0{\cdot}0247(^2\Pi_{3/2}| - 0{\cdot}0021(^2\Sigma|$. These wave-functions give $\bar{g}$(theor.) $= -0{\cdot}0229$ and α(theor.) $= +0{\cdot}0020$, which agree very well with the observed values. The observed g factor in $J = 3/2$ state, $\bar{g} = 0{\cdot}0230$ Bohr magnetons, shows that in the supposedly "non-magnetic" $^2\Pi_{1/2}$ state the NO molecule has a sizeable magnetic moment. A.

535.338.333

5993. Isotope shifts in the spectra of tin and lead. K. Murakawa. Note in *J. Phys. Soc. Japan*, **9**, *No.* 5, 876–7 (*Sept.–Oct.*, 1954).

The 5 799 Å line of Sn II is attributed to $5s5p^2\,{}^2D_{5/2} - 5s^24f\,{}^2F_{7/2}$. From the hyperfine structure it is found that $\Delta\nu(N62\text{–}N66)/2\Delta\nu(N66\text{–}N68) = 1{\cdot}37$, where N is the neutron number. For Cd the same function gives a similar value, 1·43, whereas for $2\Delta\nu(N68\text{–}N70)/\Delta\nu(N70\text{–}N74)$ a large difference is found between Sn (2·38) and Te (0·83). Results are given for Pb I 2613·7 and 4062, suggesting revision of a previous interpretation of the latter line [K. Murakawa, Abstr. 5949 (1953)]. S. T. Henderson

535.338.333

5994. Isotope shift in Cd II λ4415. K. Murakawa. Note in *J. Phys. Soc. Japan*, **10**, *No.* 4, 319–20 (*April*, 1955).

A new analysis of the hyperfine structure of the line is compared with previous work. Doubtful points still remain. S. T. Henderson

535.338.334

5995. Electron broadening and shift of spectral lines of helium. B. Kivel. *Phys. Rev.*, **98**, *No.* 4, 1055–60 (*May* 15, 1955).

The quantum mechanical treatment of electron broadening as used by Kivel, Bloom and Margenau is extended to include line shifts and is applied to the He I spectrum. The $3d \rightarrow 2p$ line is anomalous, since it has a small Stark shift and consequently a small Holtsmark broadening. For it the electron effects dominate. Comparison of this line's width and shape with others in the He I spectrum provides a simple experimental check on the theory. A.

535.343

5996. Spectra of transition-metal complexes. L. E. Orgel. *J. chem. Phys.*, **23**, *No.* 6, 1004–14 (*June*, 1955).

The electronic transitions observed in complexes of the transition-metal ions are interpreted in terms of a

slightly modified crystal-field theory. Parameters of chemical interest are derived. A.

535.343

5997. Absorption cross sections of methane and ammonia in the vacuum ultraviolet. H. SUN AND G. L. WEISSLER. *J. chem. Phys.*, **23**, *No.* 6, 1160–4 (*June*, 1955).

Absorption cross-sections in the range from 1300 to 374 Å were obtained with a two-metre radius of curvature, grazing incidence vacuum spectrograph. For methane 85 wavelengths were measured. Starting from $\sigma = 14$ Mb ($1\text{ Mb} = 10^{-18}\text{cm}^2$) at 1300 Å, the absorption first increased slowly and then rose more rapidly to a maximum of $\sigma = 56$ Mb at 960 ± 278 Å corresponding to the first ionization potential of methane. The absorption then decreased gradually to 14 Mb at 374 Å. The total *f*-value pertaining to the transitions of $2p$ electrons was found to be 6·1. For ammonia, 100 wavelengths were measured. Band absorption appeared at longer wavelengths. The continuous absorption began near 1210 Å and extended to the shorter wavelengths. The structure of the absorption contour suggested the existence of two ionization continua: a weaker one with maximum $\sigma = 21$ Mb at 1130 ± 20 Å and a larger one with its maximum of 34 Mb at 730 ± 20 Å. These two maxima corresponded to the ionization limits of the outer electrons of ammonia. The total *f*-value was found to be 5·9. A.

535.343

5998. Infrared spectra and structure of NaOH and NaOD. W. R. BUSING. *J. chem. Phys.*, **23**, *No.* 5, 933–6 (*May*, 1955).

The infrared spectra of NaOH, NaOD and mixtures of these compounds have been studied at room and liquid air temperatures. The results at room temperature, taken together with the Raman spectrum of NaOH, are consistent with the X-ray structure and hydrogen positions postulated in the present work. At liquid air temperature the spectrum of NaOD shows an unexpected complexity which cannot be explained at present. A.

535.343

5999. Line widths in the 9·6 μ band of ozone. C. D. WALSHAW. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 6, 530–4 (*June*, 1955).

Intensity measurements at low resolution and low pressures in the 9·6 μ fundamental rotation–vibration band of ozone are shown to be consistent with a mixed Doppler and Lorentz shape for the rotation lines. For collisions with air molecules the average Lorentz width for this band is shown to be $0{\cdot}078\text{ cm}^{-1}$ at 760 mm Hg and 20°C. A.

535.343

6000. Vibrational spectra of molecules and complex ions in crystals. VIII. The infrared spectrum of a mixed crystal of 1-deutero-ammonia and 2-deutero-ammonia. F. P. REDING AND D. F. HORNIG. *J. chem. Phys.*, **23**, *No.* 6, 1053–6 (*June*, 1955).

For Pt VII, see Abstr. 865 (1955). The infrared spectrum of a mixed crystal containing NH_3, NH_2D, ND_2H and ND_3 was observed at −190°C. All of the fundamental frequencies of NH_2D and ND_2H were assigned. A calculation of the 12 frequencies of these two molecules was made, using the four non-zero force constants previously obtained from NH_3 and ND_3. The average deviation from the observed frequencies was 0·6% and the maximum deviation 1·6%. It is shown that the coupling between the motions of the various molecules can be neglected. A.

535.343 : 539.133

6001. Infrared spectrum of trideuterosilane and the structure of the silane molecule. D. R. J. BOYD. *J. chem. Phys.*, **23**, *No.* 5, 922–6 (*May*, 1955).

SiD_3H has been prepared by the action of lithium aluminium deuteride on $SiCl_3H$. A parallel type absorption band has been studied with a high-resolution infrared spectrometer. Analysis of the rotational fine structure of the band gave $B_0 = 1{\cdot}7755 \pm 0{\cdot}0008\text{ cm}^{-1}$. If the assumption is made that the structural parameters of the ground state of SiH_4 are unaltered by the substitution of D for H, the Si–H internuclear distance is found to be $1{\cdot}4798 \pm 0{\cdot}0004$ Å. This is appreciably greater than $1{\cdot}45_6$ Å which is accepted at present. A.

535.343 : 548.736.4

6002. Infrared spectrum, X-ray diffraction pattern, and structure of ammonium fluoride. R. C. PLUMB AND D. F. HORNIG. *J. chem. Phys.*, **23**, *No.* 5, 947–53 (*May*, 1955).

The infrared spectrum of ammonium fluoride and deutero-ammonium fluoride at −195 and 25°C is shown to be explicable in terms of "essentially T_d symmetry requiring that the axial ratio (c/a) be 1·63. New X-ray-lattice parameter measurements show this to be true. A comparison of the spectrum of NH_4F with other ammonium salts indicates that broad bands do not necessarily accompany strong hydrogen bonds. A.

535.343

6003. Effect of a high *cis*-barrier on the microwave spectrum of hydrogen peroxide. J. T. MASSEY AND R. W. HART. *J. chem. Phys.*, **23**, *No.* 5, 942–6 (*May*, 1955).

The frequency spectrum in the microwave region and the Stark effect are obtained for the case of a potential function with a high *cis*-peak and a low *trans*-peak. Using the available experimental data on H_2O_2 it is not possible to determine whether this potential function or the *cis*-peak equal *trans*-peak potential function is correct. It is shown, however, that the microwave data can answer this question if sufficient resolution is obtained. A.

535.343

6004. Simultaneous vibrational transitions in liquids. J. A. A. KETELAAR AND F. N. HOOGE. Letter in *J. chem. Phys.*, **23**, *No.* 4, 749 (*April*, 1955).

Mixtures of CS_2 and Br_2 (0·54 mole fraction) and also of CS_2 and I_2 were investigated spectrographically. The former mixture showed sum frequencies as well as difference frequencies of bands of the two compounds. The intensity ratio of difference band to sum band yielded a value which agreed well with the theoretical value; this was also true for the ratio of the optical densities at the band maxima. The CS_2–I_2 mixture gave corresponding results. A. J. TAYLOR

535.343

6005. Infrared absorption of liquid and solid hydrogen. E. J. ALLIN, W. F. J. HARE AND R. E. MACDONALD. Letter in *Phys. Rev.*, **98**, *No.* 2, 554–5 (*April* 15, 1955).

Comparison with gaseous H_2 at 3400 atm in the range 4000–5500 cm^{-1} and assignment of the peaks.

G. F. LOTHIAN

535.343 : 535.372

6006. Vibrational structure of zinc oxide spectra. P. S. LITVINOVA. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11) 636–45 (1954) In Russian.

A system of weak maxima has been found in the absorption and emission spectra of ZnO luminophores, which can be described by an electron vibrational formula for two values of the electronic excitation. Electron transitions are due to excitation of the activator, and the absorption and emission spectra reflect the vibrational state of the ZnO lattice, into which the activator is very closely integrated.

R. C. MURRAY

535.343 : 537.228.1

Radio-frequency vibrational absorption in piezoelectric crystals. *See Abstr.* 6120

535.343

6007. Some remarks on the spectra of nitrites and nitrosamines. P. TARTE. Letter in *J. chem. Phys.*, **23**, *No.* 5, 979 (*May*, 1955).

The interpretation by Haszeldine and Jander [*J. Chem. Soc.*, **1955**, 691–5 (*Feb.*, 1954)] of the infrared and ultraviolet spectra of a series of alkyl nitrites and dialkylnitrosamines is criticized.

G. I. W. LLEWELYN

535.343

6008. Further remarks on the spectra of nitrites and nitrosamines. R. N. HASZELDINE AND J. JANDER. Letter in *J. chem. Phys.*, **23**, *No.* 5, 979–80 (*May*, 1955).

A reply to the criticisms made by Tarte (preceding abstract).

G. I. W. LLEWELYN

535.343

6009. Oscillator strengths of the vacuum ultraviolet absorption bands of benzene and ethylene. V. J. HAMMOND AND W. C. PRICE. *Trans Faraday Soc.*, **51**, *Pt* 5, 605–10 (*May*, 1955).

The oscillator strengths of the main transitions in the vacuum ultraviolet of benzene and ethylene have been measured in the vapour phase using a photoelectric detecting method. The results for benzene are discussed in relation to measurements taken in solution by Platt and Klevens. The figures for ethylene are in fair agreement with those found by Zelikoff and Watanabe.

A.

535.343

6010. The vacuum ultraviolet absorption spectrum of difluoromethane. P. WAGNER AND A. B. F. DUNCAN. *J. Amer. Chem. Soc.*, **77**, *No.* 9, 2609–10 (*May* 5, 1955).

The absorption spectrum of CH_2F_2 was investigated in the region of 535 to 2200 Å with a reciprocal dispersion of about 4·14 Å per mm, and high resolving power. Four resolved electronic transitions were found with origins at approximately 1335, 1237, 1135 and 987 Å. Below 934 Å and extending to at least 535 Å, a region of continuous absorption was observed. The transitions at 1335 and at 987 Å showed no resolved vibrational structure, while the transitions at 1237 and at 1135 Å showed well resolved vibrational structure. A tentative analysis of the vibrational patterns is presented, and the nature of the electronic transitions is discussed.

A.

535.343

6011. Analysis of the near ultraviolet absorption spectra of *ortho*- and *para*-dichlorobenzene vapors. T. ANNO AND I. MATUBARA. *J. chem. Phys.*, **23**, *No.* 5, 796–804 (*May*, 1955).

The absorption spectra of *o*- and *p*-dichlorobenzene vapours appearing in the region 2900–2400 Å and 2950–2400 Å, respectively, were photographed and measured. For the *ortho*-spectrum the band at 36232 cm^{-1} is assigned as the 0—0 band. The progression with frequency intervals of 1089 cm^{-1} starts from the stronger bands. For the *para*-spectrum, the band at 35750 cm^{-1} is taken to be the 0—0 band. The only progression-forming frequency is 1051 cm^{-1}. In both the spectra, most of the prominent bands are assigned to progressions or combinations of the possible fundamental frequencies. The fundamental frequencies are compared with the Raman values. From the vibrational analysis it is concluded that both molecules in the excited electronic states retain all their elements of symmetry in the ground states. For the *para*-compound the molecular structure in the upper state is discussed in some detail.

A.

535.343

6012. Ultraviolet absorption spectra of methylnaphthalenes at 77°K. H. M. MCCONNELL AND D. D. TUNNICLIFF. *J. chem. Phys.*, **23**, *No.* 5, 927–32 (*May*, 1955).

A simple and reliable apparatus has been developed for the determination of low-temperature ultraviolet absorption spectra in rigid glass media. This apparatus is particularly suitable for the measurement of accurate absorption intensities and has been used for the determination of the ultraviolet absorption spectra of naphthalene, 2-methylnaphthalene and 2, 6-dimethylnaphthalene at the temperature of boiling nitrogen (77°K). A comparison of these low-temperature spectra provides evidence that the electronic transition of naphthalene in the 2900–3200 Å range is symmetry allowed.

A.

535.343

6013. On the temperature dependence of the intensity of infrared absorption bands of liquids. E. J. SLOWINSKI, JR AND G. C. CLAVER. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 5, 396–7 (*May*, 1955).

Typical organic liquids show decreasing absorption with increasing temperature; possible explanations are discussed.

G. F. LOTHIAN

535.343

6014. Infrared absorption spectra of monodeuterated pyridines. F. A. ANDERSEN, B. BAX, S. BRODERSEN AND J. RASTRUP-ANDERSEN. *J. chem. Phys.*, **23**, *No.* 6, 1047–52 (*June*, 1955).

For this work 2*D*-, 3*D*- and 4*D*-pyridine were prepared from corresponding halogen compounds. The infrared spectra of the compounds in the liquid phase are reported over the spectral range 400–3200 cm^{-1}. Interpretation of the spectra is carried

through by analogy with the spectra of isotopic benzenes, pyridine and pyridine-d_5. A.

535.343 : 535.375.5 : 539.132

6015. Substituted methanes. XXVI. Raman and infrared spectral data, assignments, potential constants, and thermodynamic properties for $CHBrCl_2$ and $CDBrCl_2$. S. R. Polo, A. Palm, F. L. Voelz, F. F. Cleveland, A. G. Meister, R. B. Bernstein and R. H. Sherman. *J. chem. Phys.*, **23**, *No.* 5, 833–7 (*May*, 1955).

For Pt XXV, see Abstr. 5558 (1955). Raman displacements, semiquantitative relative intensities, and quantitative depolarization factors for liquid bromodichloromethane and deuterobromodichloromethane, as well as infrared wave numbers and per cent transmission curves for both the liquid and gas in the region 400–4 000 K (K = kaysers = cm^{-1}), were obtained and compared with previous data. Assignments were made for both molecules and a reasonable set of potential constants was determined by use of Wilson's FG matrix method. The heat content, free energy, entropy and heat capacity were calculated for 12 temperatures from 100 to 1 000°K. A.

535.343 : 539.133

6016. Infrared intensity of the C–D stretch of chloroform-*d* in various solvents. C. M. Huggins and G. C. Pimentel. *J. chem. Phys.*, **23**, *No.* 5, 896–8 (*May*, 1955).

Infrared measurements of the frequency and intensity of the C–D stretching and bending motions of $CDCl_3$ in various solvents are presented. The expected relationship between heat of solution and lowered stretching frequency is shown not to extend to $CDCl_3$. There is, however, a correlation between apparent integrated intensity of this band and the extent of interaction in the same solvent. The band is over thirty times as intense in triethylamine as in carbon tetrachloride solution. No large change in the intensity of the bending motion was observed. The infrared spectral properties of chloroform-*d* are interpreted to indicate molecular interactions similar to hydrogen bonding interactions. A.

535.343

6017. A microwave spectrometer and its applications to some organic molecules. G. Erlandsson. *Ark. Fys.*, **9**, *Paper* 28, 399–434 (1955).

A Stark-modulated spectrometer is described in some detail. Circuit diagrams of the electronic equipment are given. The instrument has been used to investigate a number of asymmetric top molecules. The observed spectra of three mono-substituted benzenes and two cyclopentane derivatives have been analysed. The former are C_6H_5F, C_6H_5Cl and C_6H_5CN. From their moments of inertia it has been found that the distortions of the benzene skeleton by the substituents are slight. A value for the C–C distance in the benzene ring has been obtained together with values for the C–F and C–Cl distances. The results agree with those obtained by other methods. The cyclopentane derivatives investigated are cyclopentanone and cyclopentene oxide, both with the formula C_5H_8O. The results on cyclopentanone confirm the assumption that a non-planarity occurs in the five-membered carbon ring. The assumed structures of the two molecules have also been confirmed. The values obtained for the principal moments of inertia of the investigated molecules are tabulated. A.

535.343

6018. Microwave spectrum and planarity of the ring of trimethylene oxide. J. Fernandez, R. J. Myers and W. D. Gwinn. Letter in *J. chem. Phys.*, **23**, *No.* 4, 758–9 (*April*, 1955).

The spectrum of trimethylene oxide from 16–42 kMc/s is observed and interpreted. The intensities require the introduction of 9 : 7 statistical weights for the vibrational levels and the dipole moment, $1{\cdot}93 \pm 0{\cdot}01$ *D* has no component $\perp$ to the ring, which all the evidence indicates to be planar.

D. H. WHIFFEN

535.343

6019. The microwave spectra of some partially deuterated methyl derivatives. I. Methyl cyanide and methyl acetylene. L. F. Thomas, E. I. Sherrard and J. Sheridan. *Trans Faraday Soc.*, **51**, *Pt* 5, 619–25 (*May*, 1955).

Rotational constants are determined for H_2DCCN, HD_2CCN, H_2DCCCH, HD_2CCCH, H_2DCCCD, HD_2CCCD and D_3CCCH. The distortion constants D_J and D_{JK} are also evaluated for the methyl acetylenes, and D_{JK} and the nuclear quadrupole coupling of N^{14} are determined for the methyl cyanides. It is shown that moments of inertia for eight isotopic species of methyl cyanide and eleven isotopic species of methyl acetylene can be fitted closely to single sets of structural parameters for each substance. Expressed to the nearest 0·001Å and the nearest minute, these are for methyl cyanide: $d_{CH} = 1{\cdot}112$Å, $d_{CN} = 1{\cdot}107$Å, $d_{CC} = 1{\cdot}458$Å, $d_{CN} = 1{\cdot}157$Å, $\angle HCH = 109°\ 16'$ ($\angle HCC = 109°\ 40'$), $\angle DCD = 109°\ 21'$ ($\angle DCC = 109°\ 35'$); for methyl acetylene: d_{CH} (methyl) = 1·112Å, d_{CD} (methyl) = 1·108Å, $d_{C-C} = 1{\cdot}458$Å, $d_{C\equiv C} = 1{\cdot}207$Å, d_{CH} (acetylenic) = 1·060Å, d_{CD} (acetylenic) = 1·058Å, $\angle HCH = 108°\ 25'$ ($\angle HCC = 110°\ 30'$), $\angle DCD = 108°\ 32'$ ($\angle DCC = 110°\ 23'$). The closeness of fit is such as to make the variations in $\angle HCH$ outside the probable error, and possible causes of this variation are discussed. A.

535.345

6020. Transmission cross sections for water spheres illuminated by infrared radiation. J. C. Johnson and J. R. Terrell. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 451–4 (*June*, 1955).

The Mie theory is used in the computation of several transmission cross-sections for absorbing spheres. For each sphere a complex index of refraction is selected such that the cross-section corresponds to that of a water sphere illuminated by infrared radiation of mean wavelength less than 14 microns. The real part of the index is a value between $1{\cdot}14 \leqslant m \leqslant 1{\cdot}42$ and the imaginary part, the absorption index, lies between $0 < mk \leqslant 0{\cdot}40$. Also included is a study of the change in the transmission cross-section as the absorption index is varied. For these computations, the real index of refraction is kept constant at $m = 1{\cdot}29$. A.

535.345

6021. Transmission of germanium in the far infra-red. I. M. MILLS AND B. CRAWFORD, JR. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 6, 489 (*June*, 1955).

Existing data on the transmission of Ge at wavelengths up to 39μ has been extended to about 55μ. Absorption bands with peaks at 340, 425 and 525 cm^{-1} were found, in agreement with previous work, and beyond 40μ the transmission was constant at about 20%. D. G. AVERY

535.345

6022. Safety hazard of tinted automobile windshields at night. H. HABER. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 413–19 (*June*, 1955).

The effects of tinted optical media, particularly of heat-absorbing automobile windshields, upon visibility distances on the highway at night are analysed theoretically. The loss percentages in visibility distances caused by replacing clear windshields with tinted ones are calculated as functions of the variables involved, viz. transmittance of the tinted optical medium, isocandle profile of the headlamp, angular size and reflectance of the target. It is found that the loss percentages in visibility distances are further dependent upon the distance of the target itself, with the losses increasing with decreasing distances. Losses in visibility distances caused by commercial brands of tinted windshields amount to between 9 and 15% at visibility distances ranging between 1 000 and 200 ft. These results agree fairly well with the data of Blackwell and with data obtained experimentally in the field by other authors. The analysis shows further that the losses in visibility distances are greatest for targets so nearly matched to the background that they may be seen even with clear windshields only at short distances. Under these conditions the losses may be as high as 30 to 45%. A reconsideration of the 70% minimum transmittance requirement for windshields in the American Standard Safety Code Z26·1–1950 is recommended. A.

535.345.6

6023. Improvements in heat-reflecting filters. L. I. EPSTEIN. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 360–2 (*May*, 1955).

A non-absorbing periodically stratified medium (abbreviated PSM) acts as a band-reflecting filter. Within a high-reflectance band, the reflectance tends to 100% in the limit as the number of periods increases indefinitely. A high-recfletance band is usually approximately centred on any wavelength such that the combined optical thickness of the layers constituting one period equals an integral number of half-waves. The integer in question is called the order of the high-reflectance band. Certain orders may be suppressed. A heat-reflecting filter can be made up of PSM's having some unsuppressed high-reflectance bands in the infrared and only suppressed bands in the visible. The longer the wavelengths reflected by the first order, the greater the number of orders in the visible which must be suppressed. Present heat-reflecting PSM's have only a single order suppressed. A method is described for designing a PSM which has two successive orders suppressed. A.

535.347

6024. Contribution to the study of the dichroism of the spectrum of single crystals of HgI_2. S. NIKITINE AND M. SIESKIND. *C..R. Acad. Sci.* [*Paris*] **240**, *No.* 12, 1324–6 (*March* 21, 1955) In French.

Single crystals at right angles to and in the direction of the *A*-axis were used. Dichroism was found in the excitation spectrum at the boiling point of nitrogen. C. TURNER

535.361.2

6025. Reflection spectra of coloured light-scattering objects. I. Z. V. ZHIDKOVA. *Zh. éksper. teor. Fiz.*, **27**, *No.* 4(10), 458–66 (1954) In Russian.

The system studied consists of an infinitely thick layer of particles of the same colour, which means that the only reflection possible is of diffuse nature. The following problems have been investigated: the effect of the degree of dispersion and of the relative index of refraction (between the particles and the connective medium) on the diffuse-reflection spectrum in the layer, and the effect of these two factors and the coefficient of absorption κ on correlation between the diffuse-reflection spectra and the true absorption of the substance from which the particles are made. The following substances were examined: 3 glasses with molecular-dispersed coloration, fuchsine, crystal violet, SiC and cobalt blue. The connective media used were: air, α-bromonaphthalene, aniseed oil, "octoil" (vacuum oil), glycerol and water. The size of particles varied from 1–2 to 1 000–1 190μ. It was found that, for powdered glasses, the absolute value of the coefficient of diffuse reflection R increases as the particle size decreases and as the relative index of refraction n_0 increases; the $-\log R(\lambda)$ curves are only in broad lines similar to absorption curves $K(\lambda)$ for the same substance in bulk, the correlation being better for higher values of the degree of dispersion and of n_0. When κ is large, the correlation disappears. F. LACHMAN

535.361.2

6026. Reflection spectra of coloured light-scattering objects. II. O. P. GIRIN AND B. I. STEPANOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 4(10), 467–76 (1954) In Russian.

Reviews theoretical work so far available, based mainly on papers of Bodo [Abstr. 8802 (1952)] Gurevich [Trudy GOI (Gosudarstvennogo Opticheskogo Instituta) **6**, *No.* 57 (1931)] and Gershun [*ibid.*, **11**, *No.* 99 (1936)], develops a new, more general, expression for the coefficient of reflection, and explains the limits of applicability of Gurevich's formula (which contains no allowance for the size of particles). At the same time the dependence is studied of reflection spectra on the dimensions of the particles and the properties of the connective medium. It is shown that the spectrum of diffuse reflection may widely differ from the absorption spectrum of the substance in bulk. F. LACHMAN

535.37.07 : 535.89

6027. A luminescent lamp for luminescence analysis. B. I. VAĬNBERG, V. P. DANILOV AND F. M. PEKERMAN. *Zh. tekh. Fiz.*, **24**, *No.* 9, 1707–10 (1954) In Russian.

Describes a low-pressure luminescent lamp of a new design, the bulb of which is made of UFS-4 glass

absorbing visual radiation and transmitting ultraviolet radiation around 3 600 Å, while the special luminophore, $Sr_3(PO_4)_2 + Ca_3(PO_4)_2 + Tl$ with radiation maximum at 3 500 Å, is deposited directly on the walls of the bulb. Relationships between luminescence yield and wavelength are graphed for different compositions of the luminophore. F. LACHMAN

535.371

6028. Decay of luminescence of silver-activated zinc sulphide after excitation by single α-particles and electrons. D. SMIDT. *Ann. Phys.* [*Leipzig*] **15,** *No.* 5–6, 325–36 (1955) In German.

The hyperbolic decay of the emission from single particle excitation is measured with respect to its dependence on excitation intensity and activator concentration. Empirical relations are established. G. F. J. GARLICK

535.371

6029. A comparison of the luminescence of calcium silicate (Mn, Pb) and zinc beryllium silicate (Mn). H. DZIERGWA AND H. LANGE. *Z. Phys.*, **140,** *No.* 4, 359–69 (1955) In German.

535.371

6030. Method of recording the decay of phosphorescence. K. SKARSVÅG. Letter in *Rev. sci. Instrum.*, **26,** *No.* 4, 397–8 (*April*, 1955).

535.371

6031. Increasing fluorescence efficiency of liquid-scintillation solutions. M. FURST, H. KALLMANN AND F. H. BROWN. *Nucleonics*, **13,** *No.* 4, 58, 60 (*April*, 1955).

The presence of certain materials, e.g. boron or water in certain scintillation solutions results in quenching. This may be compensated by enhancement of fluorescence through the addition of appropriate substances. The enhancement resulting from adding naphthalene to certain boron and water-rich solutions, is described. L. R. SHEPHERD

535.371

6032. The fluorescence quenching of anthracene, 9-phenylanthracene and 9 : 10-diphenylanthracene in the vapour phase. B. STEVENS. *Trans Faraday Soc.*, **51,** *Pt* 5, 610–19 (*May*, 1955).

The variation of fluorescence intensity of anthracene, 9-phenylanthracene and 9 : 10-diphenylanthracene excited by 3 660 Å at 300°c in the vapour phase has been investigated as a function of vapour concentration and foreign gas concentration. Evidence of strong self-quenching is found with anthracene and 9 : 10-diphenylanthracene. SO_2 reduces both the absorbed and fluorescence intensities of anthracene in a way which can be explained in terms of a thermal reaction, whilst the paramagnetic gases O_2 and NO are equally efficient in quenching the fluorescence of all three hydrocarbons according to the Stern–Volmer expression, and have no effect on the absorbed intensity. A simple photokinetic scheme accounts for the data obtained for anthracene, which appears to behave as a complex polyatomic molecule according to Neporent's definition; the quenching mechanism is discussed, and lifetimes are calculated on the assumption that the collisional quenching efficiency is unity. A.

535.371

6033. Effect of oxygen on luminescence of cadmium sulfide. S. H. LIEBSON AND E. J. WEST. Letter in *J. chem. Phys.*, **23,** *No.* 5, 977–8 (*May*, 1955).

Increase in oxygen pressure on a CdS crystal, surface excited by 3 650 Å radiation, decreases the luminescence efficiency. Oxygen is assumed to form a chemical barrier at the crystal surface where radiationless recombination is favoured. G. F. J. GARLICK

535.371

6034. Long time phosphorescence of organic crystals. H. KALLMANN, B. KRAMER AND E. SUCOV. *J. chem. Phys.*, **23,** *No.* 6, 1043–7 (*June*, 1955).

Long time phosphorescence (of the order of minutes) of anthracene, stilbene, durene and naphthalene crystals at room temperature is reported. The decays are approximately hyperbolic and the observed phosphorescence is shifted to longer wavelengths than the usual fluorescent emission. This phosphorescence is not induced by the light strongly absorbed in the substance but mainly by the weak absorption of light of wavelengths corresponding to their own fluorescent light. There are indications that this phosphorescence stems from an approximately uniform, continuous trap distribution and that such a mechanism permits a description of some of the observed behaviour. Wavelength measurements seem to indicate that this phosphorescent light emission does not originate from triplet to ground transitions. A.

535.371 : 537.312.5

6035. Model for luminescence and photoconductivity in the sulfides. J. LAMBE AND C. C. KLICK. *Phys. Rev.*, **98,** *No.* 4, 909–14 (*May* 15, 1955).

A model for sulphides activated by monovalent metals is discussed which differs in several important respects from that usually employed. Because of the net negative charge of the lattice volume surrounding the activator there is a large cross-section for trapping of holes which may be accompanied by release of a large amount of energy. This is presumed to be the transition leading to luminescence. A subsequent trapping of an electron returns the centre to its original condition. For the electron trapping there is no Coulomb field and both the capture cross-section and energy released would be expected to be small compared with the case of hole trapping. On the basis of this model, there is a simple explanation of the fast luminescence decay associated with hole capture and the slow conductivity decay associated with that of free electrons. Other well-known phenomena in the sulphides are examined on the basis of this model. In addition, predictions of this model concerning the infrared photoconductivity and infrared stimulation of luminescence have been verified by experiment on silver-activated cadmium sulphide. A.

535.371 : 537.312.5

Recombination processes in cadmium sulphide. *See Abstr.* 6149

535.371 : 539.11

6036. On the fundamental law for escape from traps. D. CURIE. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 15, 1614–16 (*April* 13, 1955) In French.

For escape of trapped electrons during phosphorescence thermal equilibrium of the trapped

electrons is assumed. This is not true but it is shown that the simple activation formula can still be justified.
G. F. J. GARLICK

535.371 : 539.133

6037. Equilibrium of hydrogen-bond formation in the excited state. N. MATAGA, Y. KAIBE AND M. KOIZUMI. Letter in *Nature* [*London*] **175**, 731–2 (*April* 23, 1955).

The effect of adding to β-naphthol different proton acceptors such as dioxane, methyl, ethyl and *n*-butyl acetate, ethyl chloracetate, etc., on the fluorescence and absorption spectra is examined. Except for the chloracetate, the additions increase fluorescence yield and spectra indicate hydrogen bond formation. A tentative reaction scheme for fluorescence and quenching is established. G. F. J. GARLICK

535.372

6038. Effect of concentration on the optical properties of solutions of 3, 6-diaminoacridine. L. V. LEVSHIN. *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 201–12 (1955) In Russian.

Changes with concentration in ethyl alcohol of the absorption, polarization and luminescence spectra, the luminescence intensity and the mean lifetime of the excited state are shown to be explicable by dimerization of the compound. The energy of activation of this must be high, since a change from 20 to 96°C scarcely affects the intensity of the peaks in the absorption spectrum of the dimer.
R. C. MURRAY

535.372

6039. Effect of concentration on the optical properties of solutions of some acridine compounds. L. V. LEVSHIN. *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 213–22 (1955) In Russian.

See preceding abstract. Changes with concentration in the absorption and other spectra, luminescence intensities and average lifetimes of the excited state of 10 acridine compounds are explained by increase of association with concentration. In some compounds this association destroys the luminescence (which is thus a property of the monomer) and in others changes its spectral composition. All compounds, except l-aminoacridine, have as crystals a luminescence spectrum further to the red than the solution, as is the case for most known luminescent substances. R. C. MURRAY

535.372

6040. Temperature sensitivities of the sensitized fluorescence spectrum of thallium. R. E. SWANSON AND R. H. MCFARLAND. *Phys. Rev.*, **98**, *No.* 4, 1063–7 (*May* 15, 1955).

An investigation of the sensitized fluorescence of thallium and mercury mixtures using a photomultiplier type of detection is discussed. Data are given to indicate the variation of the intensity of the thallium lines as a function of the temperature of the excess mercury. Explanation of results requires the use of Winan's partial selection rule, $\Delta J = 0$, in addition to generally accepted ideas concerning energy transfer, emission and absorption. A.

535.372 : 535.343

6041. Low-temperature luminescence and absorption of CdS. L. R. FURLONG AND C. F. RAVILIOUS. *Phys. Rev.*, **98**, *No.* 4, 954–5 (*May* 15, 1955).

Measurements of the emission and absorption of CdS single crystals have been made at several temperatures. At 4°K a set of emission lines in the range 4 850–5 020 Å has been found. A study of these lines together with observations at other temperatures suggests that they are emitted by a system consisting of the combination of a gas and CdS, the gas being adsorbed on the crystal. A.

535.375.5

6042. Study of chelation through Raman effect. P. G. PURANIK. Letter in *J. chem. Phys.*, **23**, *No.* 4, 761–2 (*April*, 1955).

Observed increase in the C=0 Raman frequency (at 1 669 cm^{-1}) of salicylaldehyde produced by mixing with molecules containing acceptor hydrogen atoms (e.g. phenol, methanol) is thought to be caused by transition from intramolecular H-bonding to intermolecular H-bonding. G. I. W. LLEWELYN

535.375.5 : 535.343

6043. Raman spectrum and infrared spectrum of the molecule CH_3–CD_3. R. VAN RIET. *Bull. Acad. Roy. Belgique Cl. Sci.*, **41**, *No.* 2, 188–203 (1955) In French.

Detailed results of measurements of the spectra of CH_3–CD_3 in the vapour and liquid phases are given and discussed. Comparison is made between the observed spectra of this compound and those of ethane and other deutero-ethanes, e.g. CH_3-CH_2D, CH_2D–CH_2D, CD_2H–CD_2H, CD_3–CD_2H and CD_3–CD_3. G. I. W. LLEWELYN

535.375.5.07

6044. Choice of condenser for Raman spectrum investigations. S. G. RAUTIAN. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11), 625–35 (1954) In Russian.

Uses the results obtained by Nielsen (1930, 1947), Donzelot and Barriol (1936) and, Slyusarev and Chulanovskiĭ [Abstr. 5323 (1949)] to calculate the parameters of condenser systems to be applied in the photographic and photoelectric recording of the Raman spectra. F. LACHMAN

535.375.55

6045. Raman spectrum of sulfur dichloride. H. STAMMREICH, R. FORNERIS AND K. SONE. Letter in *J. chem. Phys.*, **23**, *No.* 5, 972–3 (*May*, 1955)

From the results of measurements of the Raman spectrum of liquid SCl_2 obtained by excitation using helium radiation, the Cl–S–Cl bond angle, the bond stretching force K_{S-Cl}, and the bond deformation constant K_{β} have been calculated. G. I. W. LLEWELYN

535.375.56

6046. Raman spectroscopy of gases. H. L. WELSH, E. J. STANSBURY, J. ROMANKO AND T. FELDMAN. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 338–43 (*May*, 1955).

An apparatus for photographing Raman spectra of low-pressure gases at high dispersion is described. A multiple reflection Raman tube, 2 m long, is irradiated by two water-cooled Pyrex mercury arcs operated at 30 amp, and surrounded by a magnesium oxide diffusing screen. A two-prism glass Littrow spectrograph, $f/42$, gives a reciprocal linear dispersion of

$10 \cdot 5\,\mathrm{cm}^{-1}$ per mm; its speed is increased fifteen-fold by a cylindrical lens in front of the photographic plate. Rotation-vibrational spectra of gases at 1–3 atmos pressure can be photographed with a resolution of $1\,\mathrm{cm}^{-1}$. Various aspects of high-resolution Raman spectroscopy of gases are discussed. A.

535.376

6047. Light modulation by excitation of phosphor with alternating electric fields. H. GOBRECHT, D. HAHN AND F. W. SEEMANN. *Z. Phys.*, **140**, *No.* 4, 432–9 (1955) In German.

535.376

6048. Response of anthracene and stilbene to low-energy protons and X-rays. J. M. FOWLER AND C. E. ROOS. *Phys. Rev.*, **98**, *No.* 4, 996–9 (*May* 15, 1955).

The scintillation response of anthracene and stilbene to low-energy protons (170–570 keV) and X-rays (10–40 keV) has been investigated. In agreement with previous work at higher proton energies, the proton pulse height $v.$ energy curves are quite non-linear. The X-ray data are essentially linear down to 10 keV. This result is contrary to the reported response of these crystals to electron bombardment, but seems to be in agreement with the theory proposed by Birks. With the aid of this theory, proton response curves are obtained for stilbene and anthracene over an extended energy range. A.

535.376

6049. X-ray-induced luminescence from air. W. E. SPICER. *Phys. Rev.*, **98**, *No.* 4, 1061–2 (*May* 15, 1955).

The luminescence due to the absorption of X-rays in air has been studied in the range 600 to 250 mμ. Relatively strong peaks were found at 356, 336 and 314 mμ with lesser peaks at 388, 378 and 373 mμ. This luminescence has been associated with argon present in the atmosphere. A.

535.39 : 539.23

6050. Note on the formula for the reflection of light from glass with a thin metallic film. A. VAŠÍČEK. Letter in *Czech. J. Phys.*, **5**, *No.* 1, 103–4 (*Feb.*, 1955).

The author answers some comments on the form of an equation [Abstr. 6522 (1954)] dealing with reflection at a perfect metallic mirror. It is shown that this equation is only a special case of more general relations for reflection by a number of metal films on a dielectric substrate, and that the form of the equation results from these general equations.

D. G. AVERY

535.4

6051. A macroscopic theory of interference and diffraction of light from finite sources. II. Fields with a spectral range of arbitrary width. E. WOLF. *Proc. Roy. Soc. A*, **230**, *No.* 1181, 246–65 (*June* 21, 1955).

The results of Pt I [Abstr. 10080 (1954)] of this investigation are generalized to stationary fields with a spectral range of arbitrary width. For this purpose it is found necessary to introduce in place of the mutual intensity function of Zernike a more general correlation function $\hat{\Gamma}(\mathbf{x}_1, \mathbf{x}_2, \tau) = \langle \hat{V}(\mathbf{x}_1, t+\tau)\hat{V}^*(\mathbf{x}_2, t)\rangle$, which expresses the correlation between disturbances at any two given points $P_1(\mathbf{x}_1)$, $P_2(\mathbf{x}_2)$ in the field, the disturbance at P_1 being considered at a time τ later than at P_2. It is shown that $\hat{\Gamma}$ is an observable quantity. Expressions for $\hat{\Gamma}$ in terms of functions which specify the source and the transmission properties of the medium are derived. Further, it is shown that *in vacuo* the correlation function obeys rigorously the two wave equations $\nabla_s^2\hat{\Gamma} = (1/c^2)(\partial^2\hat{\Gamma}/\partial\tau^2)$, for $s = 1, 2$, where ∇_s^2 is the Laplacian operator with respect to the co-ordinates (x_s, y_s, z_s) of $P_s(\mathbf{x}_s)$. Using this result, a formula is obtained which expresses rigorously the correlation between disturbances at P_1 and P_2 in terms of the values of the correlation and of its derivates at all pairs of points on an arbitrary closed surface which surrounds P_1 and P_2. A special case of this formula ($P_2 = P_1$, $\tau = 0$) represents a rigorous formulation of the generalized Huygens principle, involving observable quantities only. A.

535.417

6052. The measurement of light deviation in the interference refractor. H. HANNES. *Optik*, **12**, *No.* 4, 181–8 (1955) In German.

A technique is described for the evaluation of interferograms taken with the Mach–Zehnder interferometer. In the usual method of using this instrument the optical thickness of the path is derived from fringe displacements. In the method described here the gradients of the optical thickness are obtained. There is therefore a resemblance to the schlieren technique, in this sense. The method described is illustrated by some examples. S. TOLANSKY

535.421

6053. On dependence of resolving power of Fabry–Perot etalon, Lummer-Gehrcke plate and transmission echelon on stage of resolution. S. S. MITRA. *Indian J. Phys.*, **28**, *No.* 12, 543–8 (*Dec.*, 1954).

Tables and graphs are given to show the dependence. A.

535.421

6054. Energy distribution of diffraction gratings as a function of groove form. W. FRIEDL AND B. HARTENSTEIN. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 5, 398–9 (*May*, 1955).

Some corrections are made to calculations of Stamm and Whalen [Abstr. 1596 (1946)]. G. F. LOTHIAN

535.43 : 539.32

Elastic constants of crystals from light scattering measurements. *See Abstr.* 6550

535.43 : 548.7

6055. The scattering of light in sodium chloride monocrystals. S. P. F. HUMPHREYS-OWEN. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 6, 325–33 (*June*, 1955).

The total intensity of light scattered at 90° by specimens of natural and synthetic NaCl single crystals has been investigated as a function of wavelength from 6 600 to 2 500 Å. The scattered intensity is found to be of an order 40 times greater than that expected from thermal theory, and the wavelength function is not inverse fourth power throughout the spectral region studied. Therefore only a small part of the scattering can be attributed to thermal fluctuations and the bulk is attributed to a submicroscopic block structure of the crystals. From the wavelength

function an estimate has been made of the linear dimension of the blocks, and this is found to differ little from specimen to specimen and from place to place in one specimen; it is of the order 1 500 Å. Thus the above-mentioned structure seems to be an intrinsic feature of the real structure of single crystals. A.

535.434

6056. Depolarization of light scattered by polymolybdates in acid and basic solutions. P. K. KATTI AND V. N. WANCHOO. Letter in *J. chem. Phys.*, **23**, *No.* 4, 760–1 (*April*, 1955).

Sodium molybdate is found to consist of large aggregates in acid solution, confirming conclusions of other workers. G. F. LOTHIAN

535.434

6057. Determination of dissymmetry of scattering in colored solutions. H. P. FRANK AND R. ULLMAN. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 471–6 (*June*, 1955).

The measured dissymmetry of scattered light must be corrected for light absorption. This correction arises because the path length of the light is on the average greater in the forward than in the backward direction. The correction has been calculated for angles of 45 and 135° to the incident beam. The result is a function of optical path length, width of incident beam, width of aperture at the light receiver, and absorption coefficient. A set of measurements of dissymmetry of light scattering has been conducted using a solution of polystyrene in toluene with Azoflavine S as a colouring agent. The experimental results agree with the calculation within the limits of expected error. A.

535.514

6058. The polarization of light by means of aspherical ferromagnetic particles in a homogeneous magnetic field. II. Theory. E. FICK. *Z. Phys.*, **140**, *No.* 3, 308–39 (1955) In German.

For Pt I, see Abstr. 10099 (1954). A study of the optical characteristics of a cloud of elliptical particles of γ–Fe_2O_3 when aligned by a homogeneous magnetic field. The intensity, and degree of polarization of the scattered light is shown to be dependent on (i) the strength of the applied field; (ii) the direction of observation; (iii) the wavelength of the incident unpolarized light; and (iv) the temperature of the cloud of scattering particles, since this will fix the value of the complex refractive-index of the particles. Formulae are derived for computing both distribution and polarization of the light-scatter with a transverse magnetic field. Comparison is made between theory and experimental results, and the production of polarized starlight by alignment of interstellar particles is discussed. It is deduced that in the *H* I regions, where $T = 30°K$, the required galactic field strength will lie between $7{\cdot}5\times10^{-6}$ and 6×10^{-4} oersted. D. R. BARBER

535.557

6059. Use of the Sénarmont compensator for measuring double refraction of flow. A. RICH. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 393–5 (*May*, 1955).

When the Sénarmont compensator is used for measuring birefringence in double-refraction-of-flow instruments, the cross of isocline is seen to undergo a scissors-like collapsing motion as the analyser is rotated. The position and intensity of the collapsing cross have been calculated, and are in agreement with experimental observations. From this analysis the end-point sensitivity of the compensator can be directly demonstrated. A.

535.568 : 531.717

6060. Application of high rotatory power substances to the measurement of small thicknesses. Y. LATRON. *Rev. Opt.*, **34**, *No.* 4, 204–6 (*April*, 1955) In French.

A "liquid crystal" material is used. The variation in thickness of two liquid fields crossed between analyser and polarizer is seen by a measurable variation in the rotation. The accuracy is about $0{\cdot}12\mu$. A.

535.568.1

6061. Automatic electronic polarimeter. G. F. LANDEGREN. *Rev. sci. Instrum.*, **26**, *No.* 5, 502–4 (*May*, 1955).

An electronic device for measuring the angle of rotation produced by optically active substances is described. Light, after passing through a continuously rotating polarizing element, is divided into two beams, one of which passes through the solution being tested. Each beam then passes through respective stationary polarizing elements and falls, as sinusoidally modulated light, upon respective phototubes, the output of each thereby being pulsating d.c. and passed as sinusoidal a.c. by its respective audio amplifier. Outputs of each channel are then fed to an electronic phasemeter which indicates the angular phase displacement produced by the optically active sample. A scheme for increased sensitivity involving a frequency multiplier in each electrical channel is proposed, and the possibility of adapting the arrangement to speed-of-light measurements is suggested. A.

535.6

6062. Specifying colours on the basis of measurement with a trichromatic colorimeter. F. BLOTTIAU. *Cahiers de Phys.*, *No.* 54, 37–52 (*Feb.*, 1955) In French.

The laws of proportionality and additivity underlying classical colorimetry being inexact, the author proposes that they should not be made use of in specifying colours from the results of measurements on a trichromatic colorimeter. He describes the construction of charts, each referring to colours of a given luminance viewed under specified conditions of adaptation, and explains how these charts may be used to determine the relation between colours which will look alike when the conditions of viewing are different. Certain objections to the proposed scheme are discussed in the final section. The treatment is mainly mathematical. J. W. T. WALSH

535.65

6063. Color difference comparisons in low reflectance regions (a study of the precision of spectrophotometric and colorimetric comparisons). A. R. MACDONALD AND G. P. BENTLEY. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 366–72 (*May*, 1955).

A series of tests have been performed to evaluate the relative precision of the spectrophotometer and the differential filter colorimeter for colour difference measurements at low reflectance levels. The condi-

tions and techniques of measurement are described and the results are tabulated and discussed. The superior precision of the colorimetric measurements at reflectance levels of 6% and below is demonstrated. A.

535.7

Physiological optics. Vision. *See under* "Medical science. Human physiology." Decimal classification 612.84

535.81

6064. A general equation for the choice of glass for cemented doublets. W. H. STEEL. *Austral. J. Phys.*, **8**, *No.* 1, 68–73 (*March*, 1955).

535.81

6065. Applications of infrared in the army. A. CASAL. *Rev. Opt.*, **34**, *No.* 3, 171–9 (*March*, 1955) In French.

An outline is given of infrared instruments developed for the French army. A brief account of their principles of operation is given and of the components used. R. W. FISH

535.81

6066. A note on the military applications of infrared. F. FOURNIER. *Rev. Opt.*, **34**, *No.* 3, 179–80 (*March*, 1955) In French.

Lists some successful military developments, mainly for signalling, warning of enemy approach, vision at night and detection of hot bodies. R. W. FISH

535.81 : 621.383 : 621.318.57

6067. A photoelectric sampling switch for use in double-beam optical instruments. D. M. NEALE. *J. sci. Instrum.*, **32**, *No.* 6, 223–5 (*June*, 1955).

An electrometer circuit is described having high sensitivity, logarithmic response, negligible zero drift and requiring no "backing off." The two light beams are chopped at about 5 c/s and the 5 c/s output from the photocell amplifier is sampled by a simple photoelectric switch. Two cathode followers "memorize" the switch output between sampling intervals and provide on a microammeter a steady indication of the degree of unbalance of the two beams. The circuit is very simple to construct and maintain and does not require highly stabilized supplies. A.

535.823.5

6068. Measurements of microscope stage noise. K. GOTTSTEIN. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 389–93 (1954).

A simple interferometric method has been used to measure the stage noise of the following microscopes: Cooke (M 4000), Leitz (Ortholux and Koordinaten–Komparator), Zeiss (Standard) and Koristka (M.S.2). P. ROTHWELL

535.824

6069. The influence of semicoherent illumination on the limit of resolution. Case of an annular source. G. NOMARSKI AND M. ROUSSEAU-GAUDIEX. *J. Phys. Radium*, **16**, *No.* 3, 13 S–16 S (*March*, 1955) In French.

The intensity distribution in the image formed by a microscope, whose condenser has a narrow annular pupil. The image shows greater contrast than that formed with a circular condenser pupil, either with coherent or incoherent light. R. W. FISH

535.824

6070. Contribution to the study of parasitic light in microscopy. M. AGUILAR AND M. FRANÇON. *An. Real Soc. Españ. Fiz. Quim.*, **51(A)**, *No.* 3–4, 85–90 (*March–April*, 1955) In Spanish.

Twelve objectives are studied with a special photometric apparatus in which the field of microscope and the comparison field are illuminated with the same source of light. For immersion objectives of magnification 100 a value of W between 0·02 and 0·07 was found. A.

535.833

6071. Phosphorescent telescopes. A. ARNULF. *Rev. Opt.*, **34**, *No.* 3, 168–70 (*March*, 1955) In French.

A spherical mirror system, with correcting menisci, forms an image in infrared light on a phosphorescent screen, which has been previously excited by ultraviolet light. The image is then seen in yellow light and is examined by an eyepiece. Some practical details of construction and performance are given. R. W. FISH

535.89 : 578.088.5

6072. Tungsten lamp source suitable for producing flash burns. T. P. DAVIS, L. J. KROLAC AND J. A. BASSO. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 5, 397–8 (*May*, 1955).

The source gives up to 10 cal/cm².sec. G. F. LOTHIAN

535.892

6073. A new xenon-light source for the vacuum ultraviolet. P. G. WILKINSON AND Y. TANAKA. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 344–9 (*May*, 1955).

A new vacuum ultraviolet-light source is described which emits a strong continuous emission spectrum from 1 500 to 2 250 Å. This source is constructed of Pyrex, is charged with xenon, and carries a fluorite window which allows the tube to be completely sealed off from the vacuum system. Microwave energy at a frequency of 2 450 Mc/s is used to excite the emission. Molecular xenon is presumably responsible for the continuum and the main transition is probably $^3\Sigma_u^+ \rightarrow {}^1\Sigma_g^+$ with some contribution from $^1\Sigma_u^+ \rightarrow {}^1\Sigma_g^+$. The source has been used to photograph the Schumann–Runge absorption bands of oxygen in the first order of a 21 ft vacuum grating spectrograph. A.

HEAT 536

536.2 : 621.318.4

6074. Thermal conduction in round wire coils. F. UNGER. *Arch. Elektrotech.* [*Berlin*] **41**, *No.* 7, 357–64 (1955) In German.

Theoretical. By consideration of the temperature distribution between neighbouring wires, expressions are derived for the coefficients of heat transfer in impregnated and air-spaced coils, and useful approximate formulae obtained. For coils with air spaces between the insulated wires the coefficients are considerably smaller for wires of circular than of rectangular section, provided that the conductor and insulation thicknesses in the heat flow direction are the same for both cases. S. WEINTROUB

536.2.083

6075. An experimental method of measuring the thermal conductivity of gases. A. B. CALLEAR AND J. C. ROBB. *Trans Faraday Soc.*, **51**, *Pt* 5, 630–8 (*May*, 1955).

A method is described whereby the thermal conductivities of gases may be measured down to low pressures without interference from the temperature discontinuity at the gas-solid interface which normally precludes such measurements. The thermal conductivities of simple gases are shown to be quite constant down to these low pressures but abnormal behaviour is found with complicated molecules. A.

536.21 : 536.48 : 66/67

6076. The thermal conductivity of some technical materials at low temperatures. R. BERMAN, E. L. FOSTER AND H. M. ROSENBERG. Note in *Brit. J. appl. Phys.*, **6**, *No.* 5, 181–2 (*May*, 1955).

Experimental values were determined for brass, beryllium copper, soft glass, Nylon, soft solder and Wood's metal over ranges of temperature between 2 and 90°K. Values for the heat flow along specimens (10 cm long and 1 mm^2 cross-sectional area) of annealed brass, beryllium copper, Nylon and glass when the temperatures at the ends vary from 80 to 0°K are also given. S. WEINTROUB

536.212.2 : 537.311.31

6077. The thermal conductivity and electrical resistivity of uranium. V. O. ERIKSEN AND W. HÄLG. Letter in *J. nuclear Energy*, **1**, *No.* 3, 232–3 (*Feb.*, 1955).

The methods of determining these are briefly described. The former is found to be a linear function of the temperature; the slope of the function is unchanged in passing from the α- to the β-phase. The resistivity, however, shows a discontinuity at the temperature of this phase change. W. GOOD

536.212.2 : 537.312.62

6078. The heat conductivity of superconductors below 1°K. K. MENDELSSOHN AND C. A. RENTON. *Proc. Roy. Soc. A*, **230**, *No.* 1181, 157–69 (*June* 21, 1955).

A method for the accurate measurement of thermal conductivity in the temperature region below 1°K has been developed. This method has been used to determine the heat conductivity of very pure samples of lead, tin, indium, thallium, tantalum and niobium between 0·2 and 1°K. The results have been discussed with reference to theory and to the experiments at higher temperatures. The conclusion is reached that the heat conductivity of a superconductive metal near absolute zero is identical with that of a dielectric crystal. A.

536.422.15 : 539.16

6079. Twin Knudsen effusion apparatus for small samples of radioactive materials. S. C. CARNIGLIA AND B. B. CUNNINGHAM. *Rev. sci. Instrum.*, **26**, *No.* 5, 485–8 (*May*, 1955).

The apparatus which is described has been employed in the temperature range 1 140–1 412°K, using approximately 1 mg samples of PuF_3, AmF_3 and Am metal. Radiometric essay of condensed effusates yielded vapour pressure data in the range $\sim 5 \times 10^{-7}$ mm to $\sim 2 \times 10^{-3}$ mm that were internally consistent within a mean deviation of $\pm 5\%$. The apparatus is particularly suitable for the determination of small differences in vapour pressure of similar substances. A.

536.423.15

6080. Arrangement for the measurement of vapour pressures. A. JOHANNIN-GILLES AND P. JOHANNIN. Letter in *J. Phys. Radium*, **16**, *No.* 3, 236–7 (*March*, 1955) In French.

The apparatus described consists essentially of a modified Rayleigh manometer with inclined U-tube. The inclination is measured with a micrometer and the mercury levels determined by electrical contact. The range of pressure covered is 10^{-3} to the order of mm Hg with a precision of 10^{-3} mm Hg when special precautions are taken. S. WEINTROUB

536.423.4 : 536.424.1

6081. Time lag in the self-nucleation. H. WAKESHIMA. *J. Phys. Soc. Japan*, **16**, *No.* 5, 374–80 (*May*, 1955).

An approximate but simple and general treatment of the time lag in self-nucleation is given. In this method the relation to be satisfied approximately by the rate of nucleation in non-steady state is obtained and solved without first seeking the distribution of embryos. This calculation, when applied to the problem of condensation of water vapour in a high degree of supersaturation, gives a time lag of the same order of magnitude as that obtained by Probstein who solved the problem in the ordinary way. The time lag of self-nucleation in the case of transformation in a solid is also computed. As a result a certain limitation has been set to the validity of the notion of "athermal nucleation" as proposed by Turnbull *et al.*, which presumes a large temporary lag in the change of embryo distribution when, e.g. metals are quenched in phase transformations. A.

536.46 : 535.333

6082. Investigation of powder combustion in a pressure bomb with the spectro-oscillograph. E. FÜNFER AND F. RÖSSLER. *Z. angew. Phys.*, **7**, *No.* 3, 131–7 (1955) In German.

The combustion of explosive powders is viewed through a quartz window in the bomb, its spectrum being projected on to the photocathode of an image convertor. The resulting electron beam is made to oscillate in the wavelength direction by a magnetic field, and the spectrum reproduced on the luminescent screen of the image convertor thus oscillates in front of a fixed slit which is in front of a photomultiplier. The signals are recorded on the long afterglow screen of an oscilloscope with its time base synchronized with the magnetic field. During a combustion lasting about 0·1 sec three or four spectra of diminishing amplitudes are shown on the oscilloscope screen and photographed 1 sec later. The spectra need correction since time varies along the wavelength axis, but eventually the records allow the combustion temperatures to be estimated. The combustions were found to give a region of abnormally high emission near 1 μ. S. T. HENDERSON

536.48

6083. Heat capacity and entropy of liquid He^3 from 0·23 to 2°K: nuclear alignment in liquid He^3. B. M. ABRAHAM, D. W. OSBORNE AND B. WEINSTOCK. Letter in *Phys. Rev.*, **98**, *No.* 2, 551–2 (*April* 15, 1955).

New experimental values of the specific heat *C*.

The entropy S, calculated with S $(1{\cdot}5°\text{K}) = 2{\cdot}52$ cal. deg.$^{-1}$ mole^{-1}, gives S $(0{\cdot}23°\text{K}) = 0{\cdot}86$, which is significantly $< R \ln 2$. Thus the spins must be appreciably ordered at 0·23°K. Extrapolating the $C(T)$ curve above 1·4°K smoothly to $C = 0$ at $T = 0$ and subtracting this "$C_{nonspin}$" from the measured total C, "C_{spin}" is obtained. The resulting ratio $S_{spin}/R \ln 2$, which gives the not aligned fraction of spins, agrees satisfactorily with values obtained from susceptibility measurements [Abstr. 9191 (1954)].

H. LONDON

536.48

6084. Non-linear dissipative processes in liquid helium II. H. E. HALL AND W. F. VINEN. *Phil. Mag.*, **46,** 546–8 (*May*, 1955).

Mutual friction, as defined in terms of the two-fluid model, is supposed to occur if the flow of helium II is not irrotational. In testing this proposition the propagation of second sound is studied under condition of uniform rotation. In this preliminary note it is stated that attenuation is observed which is proportional to the angular velocity. In addition dissipative effects are observed during angular acceleration and deceleration and during other types of movement in which the formation of eddies may be expected. Possible quantitative relations between velocities and dissipative forces are discussed.

R. EISENSCHITZ

536.48

6085. Comparison of the energy excitations in liquid He^3 and He^4. O. K. RICE. *Phys. Rev.*, **98,** *No.* 4, 847–51 (*May* 15, 1955).

In both He^3 and He^4 there are two types of excitation, a Debye type involving large numbers of molecules, and a localized type of excitation. The latter type is considered in this paper. In the case of He^3 the localized excitations of lowest energy can be discussed rather successfully by means of a pair-rotator model, with hindered rotation in a plane. The pair-rotator model breaks down in the case of the next higher group of excited levels; their energy is about right but there are more such levels than would be expected on the pair-rotator model. The reason for this is considered. In the case of He^4 the so-called roton excitations are of much higher energy than the excited levels in He^3, on account of the statistics and also on account of the effect of the higher density on the hindering of the rotation. These effects can be understood with the aid of the pair-rotator model. The model itself, however, breaks down for these levels, and the nature of the break-down and the probable character of the rotons are discussed. The results are also of interest in connection with mixtures of He^3 and He^4. Some remarks are appended on the possibility of a λ-transition in He^3.

A.

536.48 : 532.6

6086. Surface tension of liquid He^3 in the range 0·93–3·34°K. K. N. ZINOV'EVA. Letter in *Zh. éksper. teor. Fiz.*, **28,** *No.* 1, 125 (1955) In Russian.

Using capillaries of 0·360, 0·224 and 0·188 mm diameter the rise of liquid is observed with a cathetometer. In spite of optical distortions an accuracy of ±0·05 mm in the rise of the level is claimed. The error of the final value for the surface tension is supposed to be $< \pm 7\%$. Temperatures are measured with a resistance thermometer calibrated against the vapour pressure of He^3. Plotting surface tension against the temperature results in an almost rectilinear graph. Graphs for He^3 and He^4 are said to differ only by a shift of 1·86° on the temperature scale, corresponding to the difference of the critical temperatures. Surface tension of He^3 at 1·0 and 3·0°K are equal to 0·14 and 0·02 dyne/cm respectively. Purity of material is claimed to be 99·8% He^3.

R. EISENSCHITZ

536.48 : 536.423.45

6087. Dew points of mixtures of helium isotopes. B. N. ESEL'SON AND N. G. BEREZNYAK. Letter in *Zh. éksper. teor. Fiz.*, **27,** *No.* 5(11) 648–9 (1954) In Russian.

The apparatus consists of two containers, one being filled with liquid He^4 the other with a gaseous He^4–He^3-mixture. The pressure difference between the containers is measured as a function of the quantity of gas in the second container, the dew point showing as a discontinuity. Measurements are made with gaseous mixtures of six different compositions varying between 2 and 64% of He^3. For every mixture measurements are made at a number of different temperatures. Results are summarized in form of graphs in which the vapour pressure is plotted against the whole range of concentrations at constant temperature; graphs published correspond to 2·7, 2·5, 2·3, 2·1, 1·9 and 1·7°K.

R. EISENSCHITZ

536.48

6088. Rotation of helium II at high velocities. É. L. ANDRONIKASHVILI AND I. P. KAVERKIN. Letter in *Zh. éksper. teor. Fiz.*, **28,** *No.* 1, 126–7 (1955) In Russian.

Photographs show a slightly anomalous shape of the free surface of rotating columns of helium II. The shape does not correspond to irrotational flow of the superfluid in the two-fluid model. In experiments with rotating helium authors insert a capillary in the axis which, when heated, gives rise to a thermomechanical effect. It is found that the fountain pressure is not affected by rotation of the helium column up to 16 revolutions per second, whether the capillary is fixed or whether it rotates with the container. Observations are carried out at 2·1, 1·95 and 1·74°K. The authors emphasize the fact that in these experiments local velocities (reaching the value of 136 cm/sec) are larger than the critical velocity.

R. EISENSCHITZ

536.48 : 536.22

6089. On the heat conduction in liquid helium II. P. WINKEL, A. BROESE VAN GROENOU AND C. J. GORTER. *Physica*, **21,** *No.* 5, 345–54 (*May*, 1955).

New measurements on the heat conduction of liquid helium II in narrow slits (0·4–6μ) are interpreted in terms of the friction phenomena occurring in this liquid. The results appear to confirm the existence of a critical velocity of the superfluid, while there are indications of a small new frictional effect, which is proportional to the square of the velocity of the normal fluid. At very low temperature differences the heat transport W is proportional to the temperature difference and the cube of the slit width over a

wide range of h. This indicates the existence of a real viscosity of the normal fluid which has the same order of magnitude as that found by very different methods. Though deviations are found in the narrowest slit, these have not the character to be expected from Knudsen effects. A.

536.52

6090. Sensitivity and response time of a gas-filled thermoelectric radiation pyrometer. H. SCHLITT. *Z. angew. Phys.*, **7**, *No.* 3, 113–18 (1955) In German.

The "Pyrradio" radiation pyrometer uses NiCr–constantan elements within a gas-filled glass envelope. Formulae are derived for the sensitivity and the response time showing their dependence on the gas, thermal capacity of the receiver and the dimensions of various parts of the instrument. E. H. DOCK

536.53 : 537.226.2

Dielectric properties of pinacol hydrate: application to temperature measurement. *See Abstr.* 6108

536.532

6091. An apparatus for comparison of thermocouples. T. M. DAUPHINEE. *Canad. J. Phys.*, **33**, *No.* 6, 275–85 (*June*, 1955).

Describes a semiautomatic apparatus for routine or precision comparisons of thermocouples of the same type in the temperature range 0–1 100°C. The couples being compared are welded together at the tips and placed in a tube furnace which is heated at rates varying from 10 to 100 deg. C/min. Measurements of carefully annealed thermocouples show that in the temperature range 300–1 100°C platinum–platinum 10% rhodium thermocouple comparisons may be made to accuracies of $\pm 0{\cdot}3\mu$V ($\pm 0{\cdot}03$ deg. C) at heating velocities as great as 15 deg. C/min while accuracies of $\pm 1{\cdot}5\mu$V at velocities of 100 deg. C/min are feasible. The furnace temperature is varied by means of a motor-driven Variac with automatic reversal at peak temperature. In addition to this standard comparison procedure, provision is made for comparing corresponding elements of the couples, for suppression of all or part of the measured e.m.f., and for measuring the whole e.m.f. of all couples when a comparison of different types is desired. The system can be adapted to XY recording with total e.m.f. plotted against e.m.f. differences. A.

536.581.3

6092. An improved miniature liquefier-cryostat. G. O. JONES. *Proc. Phys. Soc.* [*London*] *B*, **68**, 320–1 (*May*, 1955).

The glass dewar of the type described by Chester and Jones [Abstr. 4766 (1953)] has been replaced by a re-entrant metal vessel, serving as the vacuum case, which can be made any shape or size and is more accessible. The outside wall being at room temperature, apertures and demountable appendages can be fitted as required. Diagrams of both types are compared and the construction of the new type is described. It is claimed that the non-use of an exchange gas only adds a few minutes to the starting time, and that the total consumption of liquid oxygen is reduced by the new design. J. J. PHIPPS

536.621

6093. Adiabatic calorimeter for measuring heats of solution at room temperature. G. C. BENSON AND G. W. BENSON. *Rev. sci. Instrum.*, **26**, *No.* 5, 477–81 (*May*, 1955).

The calorimeter vessel is hermetically sealed and suspended in a vacuum surrounded by a water jacket. The whole assembly is capable of rotation through 180° to initiate the solution process and to stir the contents. Temperatures are measured with a multi-junction copper-constantan thermocouple, temperature changes of 10^{-4}°C being detectable. The performance of the calorimeter is illustrated by some results for sodium chloride in water at 25°C. These are in reasonable agreement with the data of other workers and appear to be more self-consistent. A.

536.631

6094. Theory of the specific heat of graphite. II. K. KOMATSU. *J. Phys. Soc. Japan*, **16**, *No.* 5, 346–56 (*May*, 1955).

For previous part, see Abstr. 4323 (1952). An improvement is made by introducing the shearing elastic constant c_{44}, which is estimated by a procedure similar to that employed by Brennan. This shearing elastic constant couples the two types of vibrations, those normal to the hexagonal layers and those parallel. The theory shows that below 10°K the deviation from T^2 law becomes appreciable and the range of transition from T^2 to T^3 laws appears at a few degrees absolute. The calculated values agree with the experimental ones over the whole temperature range below 60°K. Comments are given on other recent theories. A.

536.631 : 541.113

6095. Anomaly in the low-temperature atomic heat of silver. P. H. KEESOM AND N. PEARLMAN. Letter in *Phys. Rev.*, **98**, *No.* 2, 548 (*April* 15, 1955).

Previous results [Abstr. 816 (1953)] are re-evaluated, using a new temperature scale. The anomaly is thus removed. P. T. LANDSBERG

536.658 : 541.183.5

6096. Heats of adsorption on metal surfaces. M. BOUDART. Letter in *J. chem. Phys.*, **23**, *No.* 4, 753–4 (*April*, 1955).

A discursive note on aspects of the problem of calculating the heats of adsorption of gases on clean metal surfaces. It is suggested that more elaborate calculations are necessary than are so far practically feasible. W. GOOD

THERMODYNAMICS 536.7/.8

536.7

6097. Transformation properties of the Onsager relations. G. J. HOOYMAN, S. R. DE GROOT AND P. MAZUR. *Physica*, **21**, *No.* 5, 360–6 (*May*, 1955).

The invariance of the Onsager reciprocal relations under simultaneous linear transformations of the fluxes and forces occurring in the expression for the entropy production is investigated for the cases of scalar phenomena and of vectorial phenomena (heat conduction and diffusion). The connection between these transformations follows in a natural way from the invariance of the deviation of the entropy from

its equilibrium value. The latter condition rather than the invariance of the entropy production guarantees the invariance of the Onsager relations. A.

536.7 : 530.162

On the Ising problem and Mayer's cluster sums. *See Abstr.* 5902

536.75 : 530.162 : 621.391

On the definition of entropy in information theory. *See Abstr.* 5903

ELECTRICITY 537

537.12

6098. On the introduction of a fundamental interval of time in the theory of the electron. P. CALDIROLA. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 742–3 (*April*, 1955) In Italian.

A continuation of previous work [Abstr. 3894 (1955)]. A fundamental interval of time, having the value $4\ e^2/3\ m_0c^3$ is now introduced, via the expression of the uncertainty principle. L. S. GODDARD

ELECTROSTATICS . DIELECTRICS 537.2

537.21 : 539.11

6099. A study of some problems in electrostatics. H. BONIFAS. *Rev. gén. Elect.*, **64**, *No.* 3, 149–58 (*March*, 1955) In French.

An interpretation of the electrostatic behaviour of conducting materials is given in terms of some conceptions of the electronic theory of solids. The Peltier effect and contact potential are also discussed.

A. E. KAY

537.211 : 621.317.725

6100. Absolute electrostatic voltmeter of hemispherical concentric electrodes. J. M. MALPICA. *Rev. sci. Instrum.*, **26**, *No.* 4, 333–6 (*April*, 1955).

The resultant force of electrostatic attraction between two concentric hemispherical electrodes can be determined rigorously, and it is a suitable arrangement for an absolute electrostatic voltmeter. The curved electrodes have great mechanical rigidity and constancy of form. Stability of balance between the electrostatic and mechanical forces, elimination of the error introduced by the width of separation between the moving electrode and the guard electrode and other unexpected advantages were obtained by their use. A.

537.222.2 : 537.311.33

6101. Diffusion, static charges, and the conduction of electricity in nonmetallic solids by a single charge carrier. I. Electric charges in plastics and insulating materials. S. M. SKINNER. *J. appl. Phys.*, **26**, *No.* 5, 498–508 (*May*, 1955).

The dynamic equilibrium of space charge in insulators such as ceramics, molecular crystals, or high polymers, is considered from the thermodynamic point of view with quantum-mechanical boundary conditions. The treatment constitutes the opposite extreme from the usual ohmic conduction equations; in the first paper, only the zero-current equilibrium of charge is considered. Applications are made to the observed charging of high polymers during moulding.

A.

537.222.2 : 537.311.33

6102. Diffusion, static charges, and the conduction of electricity in nonmetallic solids by a single charge carrier. II. Solution of the rectifier equations for insulating layers. S. M. SKINNER. *J. appl. Phys.*, **26**, *No.* 5, 509–18 (*May*, 1955).

The discussion of the thermodynamic equilibrium of an electron atmosphere in a dielectric is extended to the current-carrying steady state. Under the assumption that the experimental behaviour at zero current is continuous with that when there are finite electrical currents, it is found that forward and reverse currents show distinct behaviour. Expressions are developed for the electrostatic potential, field, charge density, the current-applied voltage relation, and the capacity and rectifying behaviour of dielectric layers. The non-ohmic conduction exhibits rectification, and departures from the Wagner relation are predicted, of the type observed experimentally, including turnover voltages. The contact charging of a dielectric is the zero-current limit of the non-ohmic behaviour which causes rectification. A.

537.226 : 537.311.33 : 538.566 : 539.132 : 621.315.61

6103. Dielectrics and waves. A. R. VON HIPPEL. *New York: John Wiley and Sons; London: Chapman and Hall* (1954) xii + 284 *pp.*

The work is intended for physicists, chemists and electrical engineers and treats dielectrics defined as "not a narrow class of so-called insulators, but any non-metal and even metals in a boundary case if their interaction with electric, magnetic, or electromagnetic fields is under consideration." Within this definition such subjects as dielectric breakdown, electric conduction in semiconductors, and the properties of ferromagnetics are included. The subject is treated in two sections from (*a*) the macroscopic and (*b*) the molecular approach. Under (*a*) chapters are included on permittivity and permeability, space-charge fields, Maxwell's equations, electromagnetic waves in free space and bounded conditions, various forms of polarized radiation, waveguides and resonators, optical effects, measurements on dielectrics and their treatment by lumped circuit equivalents. Under (*b*) are included the structure of atoms and molecules, energy levels, quantum theory, wave mechanics, dielectric properties as exemplifying atomic and molecular polarization, and other properties of solids. Various illustrative features, problems, and special points of interest are given in an appendix and tables of the appropriate physical constants, vector analysis methods, and other data are included. There are about 400 diagrams. C. A. HOGARTH (R)

537.226

6104. The problem of considering the internal field in the relaxation polarization in polycrystalline dipolar dielectrics. G. I. SKANAVI AND A. N. GUBKIN. *Zh. éksper. teor. Fiz.*, **28**, *No.* 1, 85–95 (1955) In Russian.

A method of calculating the internal field from experimental data on the relaxation polarization in

dipolar polycrystalline dielectrics is presented, suitable for crystals of a complicated or unknown structure. This method is interesting as enabling more accurate values of certain parameters, e.g. the potential barrier limiting the movement of relaxating dipolar or ionic groups or the natural oscillation frequency of such groups to be obtained. It also gives an idea of the character of the effective field in a dipolar dielectric which differs from the field of Lorentz's theory, and of the relations between this field and the dielectric constant at zero and infinite frequency. Since the structure of the polycrystal is assumed to be unknown, the structural coefficients cannot be used for field representation, but must be replaced by appropriate generalized coefficients. The further considerations are based on Fröhlich's generalization of Kirkwood's equation (for polar liquids) for the case of dipolar solids, and therefore on the effective dipole moment of the unit cell of the crystal. To a first approximation the relaxation polarization of dipolar cells may be characterized by a single relaxation time (single polar barrier). Certain simplifying assumptions on the energy of a dipolar unit cell are then introduced. It is found that for marked relaxation polarization the effective field differs considerably less from the mean macroscopic field than the Lorentz field. The theory was applied to certain organic dipolar crystals (oleowaxes) for which the parameters characterizing relaxation polarization could be calculated.

B. F. KRAUS

537.226.2

6105. The dielectric constant of aqueous ionic solutions. V. I. LITTLE. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 6, 357–65 (*June*, 1955).

The variation with concentration of the dielectric constant of aqueous ionic solutions at low frequencies is explained in terms of the radial ordering of solvent molecules about the ions, and by the effects of temporarily linked ion pairs. A.

537.226.2

6106. Some techniques for the measurement of impedances at metre and decimetre wavelengths and their utilization for the study of the dielectric properties of solid and liquid substances. Application to the case of some normal saturated alcohols. A. LEBRUN. *Ann. Phys.* [*Paris*] **10**, 16–70 (*Jan.–Feb.*, 1955) In French.

A full account is given of the theory and of the relative advantages of several variants of parallel-wire and coaxial-line methods of measurements at 10^6 to 10^{10} c/s. Detailed numerical values of ε' and ε'' are given for the normal C_7, C_8, C_9 and C_{10} alcohols at 20°C. Two dispersion regions are found in each case with critical wavelengths ~300 cm and ~6 cm.

D. H. WHIFFEN

537.226.2

6107. Dielectric investigations of cellulose, with special consideration of the cellophane–water system. L. T. MUUS. *Trans Danish Acad. Tech. Sci.*, **1953**, *No.* 4, 143 *pp.*

Detailed critical reviews of relevant existing theories are given in the first four chapters under the following main heads: the sorption of water by cellulose, phenomenological theory of dielectrics, "microscopic" theory [of processes], the inhomogeneity theory of Maxwell and Wagner; chapters 5–6 give details of experimental technique and results for dielectric constant, dielectric loss and d.c. conductance over the frequency range 100 c/s–100 kc/s, the temperature range 20–70°C, and moisture regains from 0 to 4·5. Chapter 7 discusses the results in terms of detailed models and calculates, e.g., the vacuum-dipole moment of a localized bound H_2O molecule and of a β-glucopyranose unit. 343 references. F. F. ROBERTS

537.226.2 : 536.53

6108. Dielectric properties of pinacol hydrate: application to temperature measurement. J. S. DRYDEN AND R. J. MEAKINS. Letter in *Nature* [*London*] **175**, 603 (*April* 2, 1955).

Dielectric dispersion, over a frequency range which is highly temperature-dependent causes the permittivity, measured at a fixed frequency of ~80 kc/s, to vary by some 5·5% per deg. C. This variation exceeds the temp. coeff. of resistance of thermistors, so that pinacol hydrate, sealed to prevent dehydration may be useful as a thermal element for measuring and controlling temperature. J. H. MASON

537.226.2

6109. New class of ferroelectrics. A. N. HOLDEN, B. T. MATTHIAS, W. J. MERZ AND J. P. REMEIKA. Letter in *Phys. Rev.*, **98**, *No.* 2, 546 (*April* 15, 1955).

Guanidine aluminium sulphate hexahydrate, $(CN_3H_6)Al(SO_4)_2.6H_2O$, was found to be ferroelectric from 200°C, which it will stand for a short time, down to the temperature of liquid N_2. The material is trigonal, with perfect cleavage in the basal plane; the direction of spontaneous polarization is along the trigonal axis. Ferroelectricity is not usually observed when electrodes are applied to naturally grown faces; the effect can be seen when new faces are generated by abrasion or cleavage. At room temperature the saturation polarization is about 0·35 microcoulombs per cm^2, and the coercive force is between 1 200 and 1 500 V per cm measured at 60 c/s. These quantities increase with decreasing temperature. The small-signal dielectric constant is about 15 along the axis and about 5 perpendicular to the axis. Essentially the same properties were found in isomorphous substances in which D_2O replaced H_2O, in which Ga^{3+} and Cr^{3+} replace Al^{3+}, and in which $(SeO_4)^{2-}$ replaces $(SO_4)^{2-}$. J. LUKASZEWICZ

537.226.2

6110. Space charge layer near the surface of a ferroelectric. W. KÄNZIG. Letter in *Phys. Rev.*, **98**, *No.* 2, 549–50 (*April* 15, 1955).

A ferroelectric semiconductor or a ferroelectric extrinsic ionic conductor can exhibit a surface layer of a thickness between 10^{-5} cm and 10^{-6} cm where saturation polarization and the corresponding piezoelectric strain prevails. This layer does not depolarize if the crystal is heated above the Curie temperature of the bulk because the properties of the space-charge layer do not depend upon the temperature as long as the conditions for dielectric saturation are fulfilled. There is considerable experimental evidence that such a layer exists in the case of ferroelectric $BaTiO_3$. In the ferroelectric KH_2PO_4 no evidence for a polarized surface layer was found. J. LUKASZEWICZ

537.226.2 : 548.736.5

6111. Dielectric, X-ray, and optical study of ferroelectric $Cd_2Nb_2O_7$ and related compounds. F. JONA, G. SHIRANE AND R. PEPINSKY. *Phys. Rev.*, **98**, *No.* 4, 903–9 (*May* 15, 1955).

Single crystals of $Cd_2Nb_2O_7$ have been grown, and studies have been carried out on these above and below the ferroelectric Curie point. The X-ray analysis confirms the pyrochlore structure, and gives the oxygen parameter $x = 0{\cdot}305$ at room temperature. The symmetry below the Curie point, −85°C, is uncertain, due to the very slight lattice distortion: c/a is about 1·000 5 if the ferroelectric phase is tetragonal. The spontaneous polarization along the cubic (111) axis is 6 microcoulomb/cm² at −180°C. Partial replacement of Cd by Pb or Ca, or of Nb by Ta, decreases the Curie temperature of $Cd_2Nb_2O_7$. Dielectric measurements revealed no anomaly in several other $A_2B_2O_7$ compounds. Lattice parameters are reported for $Pb_2Ta_2O_7$, $Y_2Ti_2O_7$ and $Cd_2Nb_2O_6$. A.

537.226.2

6112. Dielectric behavior of barium titanate in the paraelectric state. M. E. DROUGARD, R. LANDAUER AND D. R. YOUNG. *Phys. Rev.*, **98**, *No.* 4, 1010–14 (*May* 15, 1955).

The coefficients in the equation of state of $BaTiO_3$ proposed by Devonshire can be considered as describing the polarization and temperature dependence of the dielectric constant. This dependence has been studied by a dynamic method. The polarization is developed by a large-amplitude a.f. field and the dielectric constant is measured by means of a small r.f. signal. This method provides an accurate measurement of the coefficient of the P^4 term in Devonshire's equation for the free energy of $BaTiO_3$. This coefficient has been studied as a function of temperature, and, contrary to previous assumptions, has been found to have a strong temperature-dependence, decreasing linearly, with temperature. The fields which can be applied without breaking the samples are not high enough to detect any contribution due to the P^6 term at temperatures as low as only 4°C above the transition to the cubic state. A.

537.226.2 : 539.219

Dielectric properties in the systems magnesia–zirconia–titania and lime–zirconia–titania. *See Abstr.* 6543

537.226.2 : 539.234

Formation of thin films of $BaTiO_3$ by evaporation. *See Abstr.* 6545

537.226.31

6113. Dielectric losses in h.f. ceramics. N. P. BOGORODITSKIĬ AND I. D. FRIDBERG. *Zh. tekh. Fiz.*, **24**, *No.* 7, 1194–204 (1954) In Russian.

The mechanism of the dielectric losses in inorganic polycrystalline bodies is considered. Results of an investigation of the ionic relaxation losses in some halide salts and metal oxides are presented. The effects of these losses in solid solutions of metal oxides are discussed. A classification of the crystals entering the structure of modern ceramics and based on their dielectric characteristics is also presented. The more complex dielectric loss mechanisms of these ceramics are analysed. Influences of production processes, frequency of the applied voltages, temperature, humidity, impurities of the crystal lattices of the components of the solid solutions and mixtures, concentration of the main components on the losses are investigated and the results presented in tables and diagrams. B. F. KRAUS

537.226.8

6114. Field-induced melting of dielectrics. B. GROSS. *An. Acad. Brasil. Ciênc.*, **26**, *No.* 2, 289–91 (1954).

A brief formal analysis is given for the rate of progression dr/dt of the liquid/solid interface in a cylindrical condenser filled with a fusible dielectric, heat being fed in by thermal conduction mainly from the outer electrode and a constant potential difference U being maintained between the electrodes. A "law of corresponding states" is obtained in the form $dr/dt = \phi\{U/[r\ln(r/r_0)]\}$, where r_0 = radius of inner electrode and ϕ is a function to be determined. See also three abstracts following. F. F. ROBERTS

537.226.8

6115. Molecular collision theory of the Costa Ribeiro effect. S. MASCARENHAS. *An. Acad. Brasil. Ciênc.*, **26**, *No.* 2, 335–43 (1954).

Considers a possible mechanism for the freezing-in of a resultant space-charge density of ions in the solid phase as a dielectric liquid is solidified by cooling: it is assumed that molecules in the liquid phase normally incident on to the surface of the solid phase with energy greater than some value ϵ_0 are able to ionize surface molecules of the solid. From experimental data for space-charge densities it is concluded that $\epsilon_0 \simeq 1{\cdot}25$ eV for naphthalene and $\epsilon_0 \simeq 1{\cdot}50$ eV for water, the values depending slightly on the assumed orientation of the molecules of the solid at the interface. See also abstracts preceding and following. F. F. ROBERTS

537.226.8

6116. Observation of the Costa Ribeiro effect in the process of sublimation of para-phenylene-diamine. S. MASCARENHAS. *An. Acad. Brasil. Ciênc.*, **26**, *No.* 2, 345–8 (1954).

The simple experimental technique is described and some results are given, from which it is inferred that a net charge of about 2×10^{-8} coulomb/gram is frozen into the sublimed solid phase. The magnitude of the charge is about 10 times that found for naphthalene. The sign of the charge is not stated. See also abstracts preceding and following. F. F. ROBERTS

537.226.8

6117. Electro-fusion: a new phenomenon observed in the phase-changes of dielectrics under the influence of an electric field. J. COSTA RIBEIRO. *An. Acad. Brasil. Ciênc.*, **26**, *No.* 2, 349–55 (1954).

Gives details of careful experiments on the rate of melting of a core of naphthalene, previously solidified on to an inner tubular electrode, when heat is fed into the specimen through an external cylindrical surface maintained at a constant temperature a few degrees above the melting point. The rate of melting can be greatly increased by the application of a positive or negative potential of up to 2 350 volts between the inner electrode and an intermediate electrode immersed in the liquid phase: the final collapse of the solid phase can be almost discontinuous. Joule heating by the observed "discharge" current can account for only about 1% of the energy needed for

the fusion. No explanation of the effect, which is not the reciprocal of the previously observed thermodielectric effect (separation of charges due to a change of state), is offered. See also preceding abstracts.

F. F. ROBERTS

537.226.8

6118. Dielectric strength of titanates of metals of the 2nd group of Mendeleev's table at continuous and alternating ($f = 50$ c/s) voltage. V. I. SARAFANOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11), 590–4 (1954) In Russian.

The breakdown voltages of the polycrystalline materials investigated, of a composition and structure similar to the titanates of zinc, magnesium, calcium, strontium and barium, and barium tetratitanate, are ~ 2–4×10^5 V/cm. The breakdown voltage of barium metatitanate is slightly lower. The d.c. breakdown of the materials similar to zinc, magnesium and calcium titanates, and the a.c. breakdown of all the materials investigated are of the genuine electric type, the d.c. breakdown of strontium and barium titanate and, probably, of barium tetratitanate, are thermal.

B. F. KRAUS

537.226.8

6119. Dielectric strength of titanates of metals of the 2nd group of Mendeleev's table at h.f. voltages. G. I. SKANAVI AND V. I. SARAFANOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11), 595–604 (1954) In Russian.

The breakdown of polycrystalline dielectrics similar in composition and structure to strontium, zinc, magnesium, calcium titanates, and to barium tetratitanate, at frequencies above 1 Mc/s is thermal. The breakdown of the same dielectrics at frequencies from 100 kc/s to 1 Mc/s is neither thermal nor genuinely electrical in the temperature range 20–230°C (except for $SrTiO_3$ whose breakdown at $T < 100$°C is thermal) and is most likely due to heat evolution in the pores of the dielectrics, thus having "thermal ionization" character. The hypothesis of the "thermal ionization breakdown" of these dielectrics at high frequencies > 1 Mc/s is considered in detail, and its quantitative evaluation yields formulae in better agreement with experimental facts than those put forward by other authors.

B. F. KRAUS

537.228.1 : 535.343

6120. Radio frequency vibrational absorption in piezoelectric crystals. J. DUCHESNE AND A. MONFILS. Letter in *J. chem. Phys.*, **23**, *No.* 4, 762 (*April*, 1955).

With piezoelectric crystals, such as laevo chloramphenicol, in a condenser which essentially replaces the coil of a quadrupole resonance spectroscope, a number of absorption lines of width 2–20 kc/s are found between 15 and 50 Mc/s at 77–300°K. Saturation indicates a relaxation time about 1 sec and the lattice vibration nature of the spectrum is confirmed by a discussion of the temperature coefficient of frequency.

D. H. WHIFFEN

537.242

6121. Theory of the speed of precipitation of submicron particles in ionized electric fields. M. PAUTHENIER. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 15, 1610–11 (*April* 13, 1955) In French.

It is stated that thermal agitation of ions is the chief factor contributing to the charge on particles of submicron dimensions. Boltzmann's distribution law is used to derive an equation giving the number of ions captured by these particles as a function of time.

A. E. KAY

ELECTRIC CONDUCTION . CURRENTS 537.3

537.31 : 537.533 : 621.385.833 : 621.385.1.029.6

6122. Noise in one-dimensional electron beams. H. A. HAUS. *J. appl. Phys.*, **26**, *No.* 5, 560–71 (*May*, 1955).

A generalized theory is developed with the aid of the theory of four-terminal networks. No specific assumptions are made as to the input noise velocity and current modulations and their correlation at the potential minimum. The ensuing theory is simpler and more general than the corresponding theories used in the past. Transformations are discussed of the standing wave of the mean-square noise current in drift regions by means of "lossless beam transducers." It is shown that such transformations can be reduced to the formalism of conventional impedance transformations. Expressions are derived for the minimum obtainable noise figures of a velocity-jump amplifier, a klystron, and a travelling-wave tube. It is proved that these expressions present an ultimate limit for the noise figures of the respective tubes with regard to transformations by beam transducers with and without loss.

A.

537.311

6123. Phenomena in tungsten wires preceding their disintegration under the effects of a heavy current. S. V. LEBEDEV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11), 605–14 (1954) In Russian.

At a current density $j = 5 \times 10^5$ A/cm² anomalies of the same kind as previously found at $j \lesssim 5 \times 10^6$ A/cm² were observed. When the current was suddenly cut off, the tungsten did not liquefy, although its energy corresponded to that of the liquid phase. Anomalous emission was established, and also that the relation between resistance and energy was anomalous. However, no deviation from Ohm's law seems to take place according to the author's interpretation, apart from the short transient period of circuit-making. An explanation of the phenomena observed seems impossible on the present theory of metals, and the author puts forward some tentative explanations, the hypothetical character of which also extends to the assumptions on which they are founded.

B. F. KRAUS

537.311.31

6124. Resistivity of dilute alloys. D. L. DEXTER. Letter in *Phys. Rev.*, **98**, *No.* 2, 543 (*April* 15, 1955).

It is pointed out that it is often overlooked that the resistance contributions of an atom which arise from its valence difference and from its different core structure are not simply additive because of interference between them, and it is suggested that there is no justification for supposing that the effect of one atomic per cent addition should be described by the formula $r = a(\Delta Z)^2 + b$, with a and b determined only by the row of the periodic table to which the addition belongs.

W. M. LOMER

537.311.31

6125. Resistivity of dilute magnesium alloys. E. I. SALKOVITZ AND A. I. SCHINDLER. Letter in *Phys. Rev.*, **98**, *No.* 2, 543–4 (*April* 15, 1955).

Results are given for additions of Li, Ag, Cd, Al, In, Tl, Sn, Pb. The figures do not fit the relation discussed in the preceding abstract, nor any simple relation between valence difference, row of periodic table and increase of resistivity per atomic per cent addition. It is clear that the valency terms have the main effect. W. M. LOMER

537.311.33

6126. On the current noise in semiconductors. W. BAUMGARTNER AND H. U. THOMA. Note in *Z. angew. Math. Phys.*, **6**, *No.* 1, 66–8 (1955) In German.

The trapping of electrons and holes seems to give an explanation of the noise. It is pointed out in particular how the magnitude and low-frequency dependence of the noise power can be understood; the possibility of a strong correlation between low-frequency noise and photo-conductive properties of semiconductors is emphasized. A.

537.311.33 : 621.314.7

6127. The raw material problem in the field of semiconductors, metal rectifiers and the transistor. R. MANFRINO. *Telecomunicazioni*, **7**, *No.* 12, 591–8 (*Dec.*, 1954) In Italian.

The natural occurrence, production status and degree of present available purity are listed for selenium, copper, germanium, silicon, magnesium, cadmium, titanium, antimony, aluminium and tellurium. The broad fields of use and the advantages of these elements and certain of their compounds are described and future prospects summarized. S. C. DUNN

537.311.33 : 537.312.5 : 548.736.3

6128. Properties of semiconducting B–Al compounds. J. LAGRENAUDIE. *J. Chim. phys.*, **52**, *No.* 1, 34–7 (*Jan.*, 1955) In French.

Experiments on photoelectric effects, dependence of current–e.m.f. relation on illumination, reflecting power in the visible, and X-ray diffraction indicate that Wohler's Al borocarbide and the compound $B^{12}Al$ have very similar structures to B, and that the former compound has an intrinsic activation energy of 2·3 eV, and an average carrier mobility $\sim 1\,cm^2$/volt-sec, and is non-ohmic. The $B^{12}Al$ was non-metallic, and *p*-type, in all cases; it was studied as blocks formed by melting powder under vacuum.

J. HAWGOOD

537.311.33

6129. Hall mobility of optically excited carriers in germanium. W. W. TYLER AND R. NEWMAN. *Phys. Rev.*, **98**, *No.* 4, 961–5 (*May* 15, 1955).

Steady-state Hall coefficient measurements of optically excited carriers have been made for high-resistivity gold-, iron-, cobalt- and nickel-doped germanium crystals in the temperature range from 200 to 54°K. In the spectral region of impurity absorption, ($h\nu < 0{\cdot}7$ eV), carriers generated in *p*-type samples are holes; carriers generated in *n*-type samples are electrons. In the region of intrinsic absorption, ($h\nu > 0{\cdot}7$ eV), Hall coefficient measurements indicate that photoconduction is due primarily to mobile electrons in both *p*- and *n*-type high-resistivity samples. These observations suggest that, in the crystals studied, hole trapping is primarily responsible for the intrinsic photosensitivity in both *n*- and *p*-type samples. These results are qualitatively consistent with the double-acceptor model, proposed to account for the two impurity levels introduced into Ge by each of the aforementioned impurities. A.

537.311.33 : 539.23

6130. Influence of surface levels on the electric characteristics of fine-grained films of germanium, silicon and tellurium. YA. E. POKROVSKIĬ. *Zh. tekh. Fiz.*, **24**, *No.* 7, 1229–43 (1954) In Russian.

The Hall effect and the resistance of fine-grained films of germanium, silicon and tellurium were investigated within a wide temperature range. Films of varying grain sizes were obtained by condensation of the semiconductors *in vacuo* on condensers of different temperature. The electric characteristics of the films are determined by the character of the surface levels and the grain size, this being due to the large surface : volume ratio. The surface levels of germanium are acceptor levels. The activation energies of the surface levels determined from the temperature-relation of the Hall effect were found for germanium to be 0·004, 0·02 and 0·055 eV, respectively. The size of the crystal grains in the films, determined from the broadening of the X-ray spectrum lines, varied between 10^{-5} and 10^{-6} cm. The relation between Hall constant and grain size could be interpreted on the assumption that the surface levels of germanium at room temperature are populated with a density of about $3{\cdot}5 \times 10^{11}\,cm^{-2}$. It was also found that the resistance of silicon films increases very strongly with rising temperature of the condenser (i.e. with growing grain size), whereas the Hall constant does not exceed $0{\cdot}1\,cm^3$/coulomb. These characteristics are explained by the existence of an empty and a populated surface level close above each other in the middle of the prohibited band. Tellurium has acceptor surface levels directly above the populated zone. B. F. KRAUS

537.311.33

6131. Note on the shift of band edge of germanium with temperature. M. TOMURA AND E. OTSUKA. Note in *J. Phys. Soc. Japan*, **10**, *No.* 4, 313–14 (*April*, 1955).

The rate of change of E_g with temperature (assumed linear) is calculated from the use of the equation $n_i^2 = 4\ C_c C_r \exp(-Eg/kT)$ where the factors C_c and C_r are estimated in terms of recent pictures of the band model of Ge as obtained from cyclotron resonance and not from a simple spherical model.

C. A. HOGARTH

537.311.33

6132. Electron capture probability of the upper copper acceptor level in germanium. R. M. BAUM AND J. F. BATTEY. *Phys. Rev.*, **98**, *No.* 4, 923–5 (*May* 15, 1955).

The doping of a germanium sample is arranged so that the minority carrier lifetime is inversely proportional to the electron capture probability of the upper acceptor level introduced by copper atoms. It is found that the lifetime decreases exponentially with increasing temperature. A suggested interpretation

is that only electrons of energy greater than 0·22 eV above the bottom of the conduction band can enter the second copper acceptor level. A.

537.311.33

6133. Variation of noise with ambient in germanium filaments. T. G. MAPLE, L. BESS AND H. A. GEBBIE. Letter in *J. appl. Phys.*, **26,** *No.* 4, 490–1 (*April*, 1955).

Ambient conditions can produce large changes in $1/f$ noise power, even though the lifetime is not changed by changing the conditions. In some cases the spectrum may be analysed as shot noise plus $1/f^n$ noise ($n \simeq 1$) but in others a more complicated noise spectrum is obtained. C. A. HOGARTH

537.311.33 : 535.343

6134. Infrared absorption of indium antimonide. W. KAISER AND H. Y. FAN. *Phys. Rev.*, **98,** *No.* 4, 966–8 (*May* 15, 1955).

Indium antimonide samples of a wide range of carrier concentrations were measured from ~5 to 500°K, over a wavelength region of 3 to 35 microns. Experimental results on the shift of the absorption edge in degenerate *n*-type samples are presented and discussed. Both *n*-type and *p*-type samples show the same absorption at long wavelengths, after becoming intrinsic at elevated temperatures. At lower temperatures, the absorption in *n*-type samples increases with wavelength, whereas in *p*-type samples it remains practically constant over a wide wavelength region. The absorption coefficient in different samples, *n*-type or *p*-type, does not increase proportionately with the carrier concentration. Possible mechanisms for the absorption are discussed. A.

537.311.33 : 548.574

6135. Optical determination of base width in grown *n-p-n* silicon crystals. A. FOWLER AND P. LEVESQUE. Letter in *J. appl. Phys.*, **26,** *No.* 5, 641–2 (*May*, 1955).

By a sequence of etches of which details are given the emitter and collector areas are made apparent so that the base width, i.e. the distance between the emitter and collector junctions, can be measured. An extension of the work of Billig and Dowd [Abstr. 8404 (1953)]. S. WEINTROUB

537.311.33

6136. On the action of cadmium selenide layers in the selenium rectifier. H. STROSCHE. *Z. Phys.*, **140,** *No.* 4, 409–13 (1955) In German.

It has previously been suggested that the contact between *p*-Se and *n*-CdSe arising from the forming process causes the rectification. If a thin CdSe layer is painted on to the Se before fitting the counter electrode, such good rectification as usual is not obtained. From experiments on forming it is found that as little as a 10^{-7} cm thick layer of CdSe is significant. Further measurements suggest that the seat of rectification lies in a compact monomolecular layer between the Se and the CdSe or counter electrode. C. A. HOGARTH

537.311.33

6137. Study of *p-n-p* alloy junction transistor from d.c. through medium frequencies. L. J. GIACOLETTO. *RCA Rev.*, **15,** *No.* 4, 506–62 (*Dec.*, 1954).

Shockley's theory of junction transistors was developed for junctions with planar geometry and was concerned with small signal operation. In this work an attempt is made to develop a design theory for alloy junction transistors based on Shockley's theory but modified to suit the practical behaviour of junction transistors. The results show good agreement between theory and measurement, and from the equations given an alloy junction transistor could be designed so as to have particular properties. C. A. HOGARTH

537.311.33

6138. Emitter efficiency of junction transistor. T. MISAWA. *J. Phys. Soc. Japan*, **16,** *No.* 5, 362–7 (*May*, 1955).

After giving a brief review of the principles of the theory of the junction transistor, the emission efficiency of an efficient emitter is calculated in the electrostatic potential-imref scheme by extending the boundary conditions so as to apply to the case of the moderately high injection level. The electrostatic potential-imref diagram for this case is sketched. The obtained efficiency decrease is about one-half of Webster's, and is the same as Rittner's, but the input characteristics are different from the latter. A.

537.311.33

6139. The effect of field-dependent mobilities on the diffusion theory of rectification. P. T. LANDSBERG. *Proc. Phys. Soc.* [*London*] *B*, **68,** *Pt* 6, 366–8 (*June*, 1955).

It is shown that, if the mobility and diffusion coefficient of the current carriers are subjected to a much smaller fractional change as a function of position in the barrier layer than is the electric field, then many results of the general theory of barrier layer rectifiers remain essentially unchanged. A.

537.311.33 : 621.315.59 : 621.314.7 : 669.783

6140. The effective surface recombination of a germanium surface with a floating barrier. A. R. MOORE AND W. M. WEBSTER. *Proc. Inst. Radio Engrs*, **43,** *No.* 4, 427–35 (*April*, 1955).

The effect of heavily doped (alloyed) *p*-type and *n*-type surface layers on *n*-type base, and of metallic plating on *n*-type base, on the surface recombination velocity *s* has been computed on the basis of one-dimensional junction theory. The results indicate that *s* should be of the order 1 cm/sec for the heavily doped surfaces, and several thousand cm/sec for the electroplated surface. The low *s* comes about for the same reason that the injection efficiency of alloy junctions is high; the alloy junction is a very efficient emitter of minority carriers into the base and a poor acceptor of majority carriers from the base because of the high doping level in the alloyed region. Since recombination in the surface layer of minority carriers from the base requires both majority and minority carriers, the restriction of the flow of either reduces the surface recombination. However, measurements of *s* by diffusion and pulse methods on alloy junction surfaces indicate that their apparent recombination is almost the same as adjacent untreated surface, e.g. 300–500 cm/sec. It is shown that lateral current flow, due to minority carrier gradients parallel to the junction interface, and neglected in one-dimensional theory, gives rise to circulating currents which translate

the minority carriers to the nearest high-recombination surface. This hole translation property of the floating *p*-layer is used to explain the erroneously high lifetimes often observed by diffusion measurements on Si and *p*-type Ge, and certain discrepancies in effective life measurement on completed transistors. A.

537.312 : 537.531

6141. Conductivity induced in unplasticized "Perspex" by X-rays. J. F. FOWLER AND F. T. FARMER. Letter in *Nature* [*London*] **175,** 516–17 (*March* 19, 1955).

Unlike the plasticized form unplasticized Perspex has a long time constant of recovery after irradiation, and conductivity $\propto$ (dose rate)$^{0\cdot55}$. Temperature variations show an activation energy in the absence of radiation of 1·6 eV and under X-rays of 0·5 eV, and the behaviour is consistent with an exponential distribution of traps with depth. A comparison of results is given for a number of plastics. F. T. FARMER

537.312 : 537.531

6142. Conductivity induced in mica by X-rays. J. F. FOWLER AND F. T. FARMER. Letter in *Nature* [*London*] **175,** 648 (*April* 9, 1955).

The induced conductivity is small and is little dependent on temperature, and there is a rapid decay following irradiation. The activation energy of the unirradiated material is 0·45 eV and of the irradiated 0·18 eV, and the results suggest a uniform distribution of traps with depth. F. T. FARMER

537.312.5

6143. The adsorption of molecules and the photoconductivity of cuprous oxide. U. I. LYASHENKO. *Dokl. Akad. Nauk SSSR,* **87,** *No.* 1, 33–5 (1952) In Russian.

The adsorption of acetone and ethyl alcohol from the vapour phase was used to alter reversibly the electronic state of the surface of thin (1 μ) or thick (0·2 mm) specimens of the semiconductor. Photoconductivity was excited with light pulses of 3 msec separated by 115 msec intervals, and the decay curve was observed on a c.r.o. Two time constants τ_1 ($\sim 10^{-4}$ sec) and τ_2 (10^{-2} sec) are observed. τ_1 changes from $2\cdot2\times10^{-4}$ sec (vacuum 10^{-4} mm) to $5\cdot7\times10^{-4}$ sec (saturated vapour) and the photoconductivity associated with τ_1 decreases more rapidly in vapour than that for τ_2. The dark resistance increases in the vapour. The empirical relationship $\tau_1 = \tau_0(R_0/R)n$ where $n = 1\cdot3$ is obtained. The peak value of the photocurrent is plotted as a function of pressure for atmospheres of acetone, alcohol and benzene. Similar results are obtained for thick and thin specimens. The results are said to agree with the original hypothesis that the adsorbed molecules give rise to changes in the number of surface states suitable for trapping photoelectrons. W. BARDSLEY

537.312.5

6144. Barrier-layer photocells. I. D. GEIST. *Arch. tech. Messen, Issue No.* 227 (*Ref. J* 392–2) 281–4 (*Dec.*, 1954) In German.

A review article giving the present status of these devices. An extensive bibliography of recent papers is included. A. H. W. BECK

537.312.5

6145. On the properties of vacuum photocells irradiated with pulsed light. W. KLUGE AND S. WEBER. *Z. angew. Phys.*, **7,** *No.* 3, 126–31 (1955) In German.

Studies of the current–voltage–intensity curves for Ag–Cs_2O–Cs and SbCs–Cs photocells.

C. A. HOGARTH

537.312.5

6146. On the threshold of the exciton band in BaO. M. SAKAMOTO. Note in *J. Phys. Soc. Japan,* **10,** *No.* 4, 314 (*April*, 1955).

The dependence of the increase in photoelectric emission and photoconductivity in BaO for $h\nu = 2\cdot3$ eV on irradiation at shorter wavelengths is studied. The threshold energy for enhancement is $\sim 3\cdot3$ eV and is assumed to be the lowest energy for excitation production on the model adopted to explain the effect. G. F. J. GARLICK

537.312.5

6147. Alternating light measurements on photoconducting CdS as a method for the determination of mobility and trapping centre distribution. I. E. A. NIEKISCH. *Ann. Phys.* [*Leipzig*] **15,** *No.* 5–6, 279–87 (1955) In German.

The "alternating-illumination" method of determining mobility from the photovoltage developed across a CdS single crystal is discussed, and the theory shows that the mobility determined is in general not the true microscopic mobility but one governed by trapping centres. C. A. HOGARTH

537.312.5

6148. Alternating light measurements on photoconducting CdS. II. E. A. NIEKISCH. *Ann. Phys.* [*Leipzig*] **15,** *No.* 5–6, 288–301 (1955) In German.

The theory developed in Pt I is tested experimentally for CdS single crystals with temperature, frequency, wavelength and intensity as measuring parameters. C. A. HOGARTH

537.312.5 : 535.371

6149. Recombination processes in cadmium sulfide. J. LAMBE. *Phys. Rev.*, **98,** *No.* 4, 985–92 (*May* 15, 1955).

An experimental study has been carried out on the photoconductivity and luminescence of cadmium sulphide. The two main properties investigated were the photoconductive spectral response, and the relationship between luminescence and photoconductivity. It is found that the observed spectral response can be explained in terms of the dependence of lifetime of conduction electrons on the wavelength of exciting light. The rise and decay of photoconductivity and luminescence have been examined for silver-activated CdS, and for the red and green luminescence of unactivated CdS. It is found that the decay of luminescence is much more rapid than the decay of photoconductivity. An explanation for this behaviour is offered, based on the assumption that the luminescence results from the recombination of localized electrons and free holes. A.

537.312.5 : 535.371

Model for photoconductivity in sulphides. *See Abstr.* 6035

537.312.5 : 537.311.33

6150. "Gate modulation" of electromagnetic radiation. K. Lehovec. *J. appl. Phys.*, **26**, *No.* 5, 495–6 (*May*, 1955).

The space-charge layer at a *p–n* junction is a region of low concentration of electrons and holes, and therefore exhibits less absorption than the bulk of the semiconductor for radiation of sufficiently long wavelengths. Thus the space-charge region of a *p–n* junction provides an optical window of a width which can be modulated by an applied field. A quantitative estimate of this effect is given. Because of an obvious relation to unipolar transistors, the name "gate modulation" is proposed, as opposed to the "injection modulation" discussed previously [Abstr. 861 (1953)].

A.

537.312.5 : 548

6151. On the photoconduction of silver bromide crystals. L. Jung. Note in *Naturwissenschaften*, **42**, *No.* 5, 122 (1955) In German.

The effect of bromine ion concentration on rate of rise of photoconduction with time in silver bromide is investigated. Bromine concentration can be enhanced by substitution in the lattice of divalent anions. An explanation of the enhancing is proposed.

G. F. J. GARLICK

537.312.6

6152. Electrical resistance of copper–gold alloys at low temperatures. E. Passaglia and W. F. Love. *Phys. Rev.*, **98**, *No.* 4, 1006–10 (*May* 15, 1955).

The resistance of copper–gold alloys of composition 25, 37·5, 50, 62·5 and 75 atomic per cent gold has been measured as a function of temperature from room temperature to 2°K in states slowly cooled and rapidly quenched from above the ordering temperatures. The room temperature resistivities agree with those previously obtained by Johanssen and Linde. The residual resistances are high in both the quenched and slowly-cooled states, but the ratio of residual resistance to the ice point resistance was found to be appreciably lower in the slowly-cooled states for the 25 and 50 atomic per cent gold composition. The other compositions showed no such difference in the residual resistance ratio for the quenched and annealed states. Values of Debye temperature calculated by means of the Grüneisen function were found to be strongly temperature dependent, and no appreciable difference was found in the Debye temperatures of the quenched and slowly-cooled states. The Debye temperatures at 75°K were found to obey the equation: $1/\theta_{AB^3} = x/\theta_A^3 + (1-x)/\theta_B^3$. Hysteresis anomalies of the order of 1% were found in the neighbourhood of 225°K.

A.

537.312.62

6153. Trapped flux in superconductors. A. B. Pippard. *Phil. Trans A*, **248**, *No.* 941, 97–129 (1955).

When a magnetic field is applied to a superconductor the normal state may be restored, and on removing the field the superconducting state is re-established, usually with a proportion of the field trapped in normal channels. The amount of flux trapped has been studied systematically as a function of temperature in rods of pure tin and of tin alloyed with indium up to 3%. In order to obtain significant results the specimens must be single crystals, homogenized by prolonged annealing, and having well-polished surfaces. The proportion of flux trapped is very small (~0·1%) in pure tin, increasing steadily as the indium concentration is increased. For indium concentrations less than about 2·3% the proportion trapped tends to zero as the temperature tends to the transition temperature. For greater indium concentrations there is a sharp rise in trapping to a very high value (~50%) at the transition temperature. The trapped flux is rather firmly bound. In order to account for these results a model of the superconducting state is developed, based on the theories of London and London and of Gorter and Casimir, and incorporating the idea of coherence. Typical processes such as spontaneous nucleation of the superconducting phase are analysed and used to discuss the factors influencing the coalescence of adjacent superconducting domains, which is an essential part of the trapping mechanism. It is concluded that for not too great indium concentrations coalescence is achieved only through the presence of flaws, and that the sudden change in behaviour at 2·3% indium marks the beginning of spontaneous coalescence. The model appears to be capable of accounting qualitatively for most of the details of the observed behaviour.

A.

537.312.62

6154. Destruction of superconductivity in the field due to the current carried and a transversal external field. L. Rinderer. Note in *Z. Naturforsch.*, **10a**, *No.* 2, 174–5 (1955) In German.

The results of resistance measurements with a tin wire at 3·5°K (critical magnetic field $H_K = 29{\cdot}8$ oersted) are shown as lines of equal resistance R/R_n in the H_I–H_T plane, H_I being the magnetic field due to the current and H_T the value of an applied transversal field. The results are in qualitative agreement with the current view that in the transition region the wire divides into a normally conducting zone where $H > H_K$ and a zone in the intermediate state in which the conductivity is > normal. For

$$H_K\{1 + 2(H_T/H_K)^2/[2(H_T/H_K) + 1]\} < H_I$$

the resistance is nearly independent of H_T, the field H_T merely shifting the central intermediate zone until it touches the surface of the wire. The normal limit of the intermediate state is extended by the current to values of $H_T > H_K$ (theoretically to $H_T = H_K + H_I$, experimentally $H_T \simeq H_K + \frac{1}{2}H_I$) owing to the opposing direction of $\vec{H_I}$ and $\vec{H_T}$ at one side of the wire.

H. LONDON

537.312.62

6155. On the superconductivity of Bi_4Rh and Bi_2Rh. N. E. Alekseevskiĭ, G. S. Zhdanov and N. N. Zhuravlev. *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 237–40 (1955) In Russian.

Crystals of three modifications of Bi_4Rh and of two of Bi_2Rh were separated and it was found that $\beta-Bi_4Rh$ became superconducting at 3·2°K and $\gamma-Bi_4Rh$ at 2·7°K; $\alpha-Bi_4Rh$ did not become superconducting down to 0·1°K, α and $\beta-Bi_2Rh$ did not become superconducting down to 1·3°K. These facts

are discussed in relation to the variability of transition temperature of Bi–Rh alloys with heat treatment.

D. SHOENBERG

537.312.62

6156. Stability of a phase boundary inside a superconductor. F. BECK. *Phys. Rev.*, **98**, *No.* 4, 852–6 (*May* 15, 1955).

According to the London–von Laue theory a phase boundary between superconducting and normal-conducting phases inside a superconductor can exist in a stationary state in the presence of a critical magnetic field. It is shown here explicitly that such a boundary is not in stable equilibrium against variations which lead to a periodic perturbation of the shape of this boundary. In connection with Pippard's idea of a finite transition region the discussion gives an outline of the meaning of this instability for the breakdown of superconductivity in the critical field. A.

537.312.62 : 536.212.2

The heat conductivity of superconductors below 1°K. *See Abstr.* 6078

537.312.62 : 538.222

6157. Paramagnetism observed at the superconducting transition. Y. SHIBUYA AND S. TANUMA. *Phys. Rev.*, **98**, *No.* 4, 938–9 (*May* 15, 1955).

Measurements have been performed on the paramagnetic effect in superconducting tin. The current minimum, I_0, for the appearance of the paramagnetic effect is represented in the $(I-H-T)$ space by the simultaneous equations $I_0 = \xi\gamma d(T_c-T)$ and $H_0 = \xi(T_c-T)-I_g/\gamma d$. Here I_g, γ, T_c and ξ are the characteristic constants of the superconductor and have the values 1·2 amp, 0·23 amp/mm oersted, 3·73°K and $1{\cdot}1\times10^2$ oersted/deg respectively for the case of tin. H_0 and d are the magnetic field in oersteds and the specimen diameter in mm respectively. It has been shown that the formula $I_0 = I_g + \gamma dH$ hitherto accepted for the minimum current requirement is the one for the orthogonal projection of the critical line in the $(I-H-T)$ space on the $(I-H)$ plane. It seems that there is a lower limit of specimen diameter for the appearance of the paramagnetic effect, which is $1{\cdot}3\times10^{-2}$ mm for the case of tin. A.

537.312.8

6158. Resistivity in metals. *Nature* [*London*] **175**, 544–6 (*March* 26, 1955).

Resistivity changes by plastic deformation of polycrystalline metals. H. G. VAN BEUREN AND P. JONGENBURGER (544–5).

Annealed polycrystalline wires of high-purity copper and silver were deformed in tension and torsion and at temperatures of 20 and 77°K. In most samples resistivity increased as a power of the strain; in most cases the exponent was 1·2–1·4. The effect of twisting before extension is to raise the resistance for unit strain from 0·06$\mu\Omega$ cm by a factor 1·3 for 0·1 torsional strain, for all samples. These results can be explained if most of the resistivity is due to point defects created by the intersection of dislocations, and points to an initial density of dislocations of $3\times10^8\,\mathrm{cm}^{-2}$.

Extra resistivity due to interstitial atoms in copper. P. JONGENBURGER (545–6).

An attempt is made to estimate the resistivity of an interstitial atom by regarding it as composed of two additive parts, one being the scattering from the atom itself, and the other the result of the displacement of the neighbouring atoms from their lattice sites. The first gives a result, rather uncertainly, of about 1–2$\mu\Omega$ cm per cent interstitials. The second is estimated by using calculated local displacements to determine a mean square displacement, whose resistivity is then estimated by comparison with thermal resistance effects to be 3·5$\mu\Omega$ cm/per cent.

W. M. LOMER

537.312.8

6159. Variation of magnetoresistivity of AuCu with degree of order. B. WIENER, P. SCHWED AND G. GROETZINGER. *J. appl. Phys.*, **26**, *No.* 3, 609–12 (*May*, 1955).

The room temperature resistivity and the magnetoresistivity of AuCu have been investigated as a function of the degree of order. Measurements were made first of all on samples quenched to room temperature after reaching equilibrium at temperatures below the Curie point. In addition measurements were made on samples which were first disordered by quenching from a temperature above the Curie point, were then annealed for various lengths of time at 265°C, and were finally quenched to room temperature. The coefficient of magnetoresistivity equals $1{\cdot}8\times10^{-12}$ and 6×10^{-14} gauss^{-2}, respectively for the completely ordered and completely disordered alloy. The equilibrium curve for the magnetoresistivity shows a minimum at 365°C and a pronounced maximum at 388°C which is close to the transition temperature for the phase change of AuCu I to AuCu II. No such extremes in the value of the coefficient of magnetoresistivity occur during the annealing of a thermally disordered sample. A.

537.321

6160. On the limits of the practical applicability of Pisarenko's formula. On the question of the temperature dependence of thermo-electric power in impure semiconductors. T. A. KONTOROVA. *Zh. tekh. Fiz.*, **24**, *No.* 7, 1291–7; *No.* 9, 1687–96 (1954) In Russian.

(1) Theoretical. Discusses the accuracy of the classical (Pisarenko) approximation

$$\alpha = \pm\frac{k}{e}\{A-\ln n + \ln[2(2\pi m^*kT)^{3/2}/h^3]\}$$

to the thermo-electric power α of a semiconductor. Here n is the number of carriers. The constant A depends on the scattering mechanism. By comparison with the exact expression it is concluded that while the assumption of a Boltzmann distribution is valid only when $n < 3\times10^{18}\,\mathrm{cm}^{-3}$, at room temperature, the above formula remains good within 15% up to $n = 4\times10^{19}$ when the scattering is caused by acoustic modes, and up to $n = 10^{20}$ in ionic crystals.

(2) Theoretical. Treats the thermo-electric power of a semiconductor in the extrinsic range. When classical statistics are valid $\alpha \simeq \pm\frac{k}{e}(\text{const.}-\mu^*)$. Here μ^* is the reduced Fermi level, and becomes very large at low temperatures. It is then pointed out that if the electron gas is in fact degenerate at very low temperatures, as is suggested by experiments on the

Hall effect at helium temperatures, the thermoelectric power there will be linear in T, and will join the classical curve at some intermediate temperature to give a behaviour qualitatively similar to that observed in Ge. The author concludes that although the Gurevich effect is probably present and important, his mechanism may explain part of the observed effects. J. M. RADCLIFFE

537.322

6161. Seebeck effect in silicon. T. H. GEBALLE AND G. W. HULL. *Phys. Rev.*, **98**, *No.* 4, 940–7 (*May* 15, 1955).

The Seebeck effect has been measured from liquid hydrogen temperatures into the intrinsic range for a series of single-crystal silicon samples in which varying concentrations of donor and acceptor atoms have been incorporated. Large values of Seebeck voltage believed to be caused by the type of phonon-electron coupling previously postulated as occurring in germanium have been found. This effect is found to be dependent upon charge carrier concentration, and upon sample dimension below 100°K. A low-temperature reversal of the sign of the Seebeck voltage is observed for large carrier concentrations. It is understandable in terms of impurity band conduction. The behaviour above room temperature into the intrinsic range is found to be consistent with electrical conductivity data. A.

537.323

6162. Reference tables for thermocouples. H. SHENKER, J. I. LAURITZEN, JR, R. J. CORRUCCINI AND S. T. LONBERGER. *Circ. Nat. Bur. Stand., No.* 561, 84 *pp.* (1955).

Expanded reference tables for platinum *v.* platinum–10% rhodium, platinum *v.* platinum–13%-rhodium, chromel–alumel, iron–constantan (modified 1913), copper–constantan, and chromel–constantan thermocouples are given with temperature in degrees Celsius (centigrade) and Fahrenheit and electromotive force in millivolts as the arguments. The tables are based upon the absolute electrical units and the International Temperature Scale of 1948. A.

537.324 : 621.362

6163. Silicon solar energy converters. M. B. PRINCE. *J. appl. Phys.*, **26**, *No.* 5, 534–40 (*May*, 1955).

Theory is given for the design of silicon solar energy convertors commonly known as the Bell Solar Battery. Values are given for the various parameters in the design theory. Experimental data are presented and compared with the theoretical relations based on a simple model. Units can be made with up to 6% efficiency in the conversion of solar radiant energy to electrical energy. An important factor in obtaining such high efficiencies is the reduction of the series resistance of the cell to as low a value as possible. A.

537.362

6164. Evaluation of true zeta potential of the particles of a diaphragm, taking surface conductivity and phase volume ratio into account. B. N. GHOSH. Note in *Naturwissenschaften*, **42**, *No.* 5, 121 (1955).

The electro-osmotic equation of a diaphragm formed by spherical particles of radius R and having pores of radius r is $\xi/\xi_a = 1 + \alpha(2\chi/rS)$ where χ is the specific surface conductivity, S the bulk conductivity of liquid in the pores, and $\alpha = 3r/2Ra$, where a is the phase volume ratio of liquid to solid in the diaphragm. For high compression $\alpha \rightarrow 3{\cdot}27$, in good agreement with experimental values for filter papers. J. H. MASON

ELECTRIC DISCHARGES 537.52

537.523

6165. The delay in the formation of discharges in air. I. E. BALÝGIN. *Zh. tekh. Fiz.*, **24**, *No.* 7, 1187–93 (1954) In Russian.

At atmospheric pressure and in spark gaps of 100, 50 and 10 mm length the formation of the avalanche, streamer and main discharge are completed within $3{\cdot}5$, $2{\cdot}5$ and $1{\cdot}7\times10^{-7}$ sec, respectively. At pressures of 600–500 mm Hg the initial (avalanche) stage of the discharge is prolonged, but the discharge mechanism still remains of the streamer-type even in the absence of appreciable over-voltages across the spark gap. At pressures of 400–50 mm Hg the breakdown mechanism differs from that of a Townsend discharge, but also from a streamer-mechanism. In this pressure range a retarding stage is observed when deionization processes considerably delay the formation of the discharge. The total duration of the formation of the discharge depends on pressure and the magnitude of the overvoltage. At pressures of the order 50 mm Hg the formation may be extended to $\sim 10\,\mu$sec. B. F. KRAUS

537.523

6166. Studies of secondary processes of low frequency electric discharge with glass electrodes. B. D. KHOSLA AND N. A. RAMAIAH. *Z. phys. Chem.* [*Leipzig*] **204**, *No.* 3–4, 223–34 (*May*, 1955).

A low frequency (50 ~) electric discharge with dielectric glass electrodes in iodine vapour has been investigated by a cathode-ray oscillograph. The r.m.s. value of the conductivity was contributed by two types of pulses produced by secondary electrons released from the cathode and generated in the gas phase. The results suggested that positive ionic bombardment on the cathode and photo-ionization in the homogeneous gas phase were the two significant mechanisms responsible for the inception and maintenance of the discharge, respectively. A.

537.523

6167. Self propagating intermittent discharge. W. S. BOYLE. *J. appl. Phys.*, **26**, *No.* 5, 584–6 (*May*, 1955).

When a constant current pulse is applied to a pair of electrodes at small separations in air a series of electrical discharges takes place. These are characterized by a fixed distance between successive discharges. The intermittent nature of the discharge is determined by the local circuit and the spatial distribution of a series of discharges results from the blast wave which is propagated from each discharge. Measurements of the propagation distance as a function of the time interval between discharges and the energy released in each discharge are in qualitative agreement with those predicted from the theory of an intense explosion. The voltage transients across the

electrodes show that during a series of discharges the breakdown voltages remain substantially constant and equal to the minimum breakdown voltage in air. This is attributed to the fact that the discharge can always find a low-density region which is quite near the front of the blast wave where the conditions for minimum breakdown voltage can be satisfied. A.

537.523.3

6168. The electric wind [effect] in room air. C. Heiser and P. Kunze. *Ann. Phys.* [*Leipzig*] **15,** *No.* 5–6, 249–54 (1955) In German.

Describes a study of electric wind in various corona discharge arrangements. Point-plane and point-sphere (the latter made in a mesh form) electrode systems are described. A micromanometer technique for air-velocity (dynamic pressure) measurements is briefly mentioned. Velocities vary downwards from ~100 cm/sec as a maximum. J. D. CRAGGS

537.523.5

6169. The temperature of, and current density at, the cathode of high-current carbon arcs. P. Guillery. Note in *Z. Naturforsch.*, **10a,** *No.* 3, 248–9 (1955) In German.

From photographic records of carbon arcs carrying 30–600 A, cathode current densities, cathode brightness and cathode erosion rates were estimated. These quantities are plotted as a function of current. Cathode current densities reach ~5 000 A/cm^2. J. D. CRAGGS

537.523.5

6170. The temperature and thermal equilibrium in iron arcs. F. Burhorn. *Z. Phys.*, **140,** *No.* 4, 440–51 (1955) In German.

Describes experimental studies of temperatures in an iron arc. Doppler width measurements, with a Fabry–Pérot interferometer, of iron lines (e.g. λ4302 Å) enable gas temperatures to be measured. Radial variations of gas temperatures are given and show a fall from about 6 500° at the axis to ~3 000° at 1 mm radius. Electron temperatures, measured from absolute continuum intensities and from line intensity ratios agree well with the gas temperatures. Various corrections to be made, etc., are described. J. D. CRAGGS

537.523.5

6171. Excitation processes and the theory of the arc discharge. A. E. Robson and A. von Engel. Letter in *Nature* [*London*] **175,** 646 (*April* 9, 1955).

Describes a new theory of the cathode electron emission mechanism in non-refractory cathode arcs. It is suggested that the electron emission (current density ~10^6 A/cm^2) is produced by the impact of excited atoms, whose potential energy exceeds the cathode work function, back scattered to the cathode from the cathode spot region. The return distance is too short for the excited atoms to radiate before reaching the cathode. Supporting data for a mercury arc are given. J. D. CRAGGS

537.525

6172. Ignition voltage of the discharge in mercury vapours. L. G. Guseva and B. N. Klyarfel'd. *Zh. tekh. Fiz.*, **24,** *No.* 7, 1169–78 (1954) In Russian.

The curve of the initiation of the discharge obtained for mercury up to 160 kV may for the interval of the values p_0d from 0·1 to 0·036 mm Hg. cm be expressed by the empirical relation U_{mean} (kV) $= 0{\cdot}21/(p_0d)^2$. The results obtained for nickel, iron and graphite cathodes do not reveal any special influence of the cathode material which agrees with the assumption of a mono-molecular film of mercury atoms on the electrode surfaces. The analysis of the elementary processes taking place in the discharge gap and at the electrodes shows that an interpretation of the left branch of Paschen's curve is possible without resort to Dempster's hypothesis, assuming the existence of individual points on the cathode with very high values of the coefficient ($= 1/Q$, where Q is the mean number of ionizations by an electron on the way from cathode to anode). It is necessary to consider the influence of processes like recharging of the ions, reflection of the electrons at the anode, ionization of the gas by positive ions and improved efficiency of the expulsion of electrons from the cathode due to the action of multiply charged ions. In the range of values of p_0d of 0·2–0·4 mm Hg.cm the curve of discharge inception in mercury vapours has a zigzag section similar to that found by Penning in helium. B. F. KRAUS

537.525

6173. Elementary processes in the formation of the high voltage impulse discharge at low pressures. É. M. Reĭkhrudel', A. V. Kustova and A. G. Zimelev. *Zh. tekh. Fiz.*, **24,** *No.* 7, 1179–86 (1954) In Russian.

An oscillographic investigation was carried out of the impulse discharge at 50–110 kV, pressures 10^{-4}–10^{-1} mm Hg in helium argon, air and mercury vapour. The electrode distance varied between 5 and 17 cm. The relation between time of formation of the discharge and peak value of the current on one hand, and various influencing factors, enabled two specific characteristics of the discharge type to be distinguished, viz. the emergence during the first stage of the discharge of a space charge which has a density varying along the discharge tube and having a maximum at the cathode, and therefore leading to the formation of the cathode parts of the discharge already during the first stages of its development, and, secondly, that the greatest influence on the formation of a discharge of high current density has, during the initial as well as during the following phases, the compensation of the negative space charge by positive ions all over the discharge space. A plasma is formed during the second stage of the discharge in a pressure range which depends on the nature of the gas. B. F. KRAUS

537.525

6174. Composition of the interelectrode prebreakdown current in high vacuum. H. C. Bourne, Jr. *J. appl. Phys.*, **26,** *No.* 5, 625–6 (*May*, 1955).

Thermal rise measurements on vacuum-insulated electrodes subjected to steady gap voltages in the range of 80 to 100 kV show that the interelectrode pre-breakdown current is composed chiefly of negatively charged particles. With aluminium electrodes the negative particles outnumber the positive particles

(ions) by at least 300 to 1. With steel electrodes, the ratio is greater than 1 000 to 1. A.

537.525 : 534.21

On electro-acoustic waves in gas discharge plasma. *See Abstr.* 5946

537.525 : 537.534.9

6175. Role of positive ions in high-voltage breakdown in vacuum. H. C. Bourne, Jr, R. W. Cloud and J. G. Trump. *J. appl. Phys.*, **26**, *No.* 5, 596–9 (*May*, 1955).

Measurements were made of the electron emission from targets of magnesium, aluminium, steel, copper, gold and lead when bombarded by ions from hydrogen, helium, nitrogen, xenon and mercury. The ions, whose energy was varied over the range from 10 to 140 kV, were produced by ionization of the residual gas in the anode electrode and emerged through a small opening into an essentially uniform accelerating field. An initial rapid rise of electron emission with ion energy was followed in all cases by a slow linear increase. The emission ratio varied from 2 to 20 and was maximum for nitrogen ions on steel. The effect of extractive gradient at the bombarded metal surface was slight and no simple dependence on the nature of the ion or of the bombarded metal was observed. The significance of these measurements on the electron-ion interaction theory of high-voltage breakdown in vacuum is discussed. A.

537.525.3 : 537.525.72 : 537.525.8

6176. The influence of light on the mechanism of gaseous discharges (Joshi effect). S. R. Mohanty. *Z. Phys.*, **140**, *No.* 4, 370–5 (1955) In German.

A general discussion of various aspects of electrodeless corona discharges, at low pressures, when irradiated externally. 38 references. J. D. CRAGGS

537.525.3 : 537.525.72 : 537.525.8

6177. The electrode surface–gas interface as the seat of the Joshi effect under silent electric discharge. S. R. Mohanty. Note in *J. Phys. Soc. Japan*, **9**, *No.* 5, 878–9 (*Sept.–Oct.*, 1954).

Describes further experiments on the Joshi effect (dependence of current on external illumination) in oxygen external electrode tubes. The results confirm the "surface" rather than the "gas phase" mechanism. J. D. CRAGGS

537.525.8

6178. Self induction and inertia effects [Nawerking] in gaseous discharges. C. van Geel. *Delft: Technische Hogeschool* (1955) 135 *pp.* In Dutch, with summary in English (4 *pp.*).

A comprehensive treatment, in the most general terms, of discharges where properties (e.g. current and voltage drop) vary with time. Various specific cases may be treated, e.g. a d.c. discharge carrying a small superimposed a.c. or a discharge with a negative current-voltage characteristic. Conditions of discharge stability are considered in terms of the discharge resistance, inductance, etc. J. D. CRAGGS

537.525.8

6179. On the theory of high-frequency low-pressure discharges. The calculation of electron distribution function. J. Salmon. *J. Phys. Radium*, **16**, *No.* 3, 210–18 (*March*); Erratum, *No.* 5, 384 (*May*, 1955) In French.

Derives an expression for the distribution of electron energies in a high-frequency discharge. Account is taken of elastic and inelastic collisions. The distribution is, to a first order, Maxwellian for the conditions studied. An expression is derived for the electron temperature, and also for the electron density in terms of discharge parameters. J. D. CRAGGS

537.525.8

6180. The direct current associated with microwave gas discharge between coaxial cylinders. IV. K. Mitani. *J. Phys. Soc. Japan*, **16**, *No.* 5, 391–7 (*May*, 1955).

For Pt III, see Abstr. 493 (1954). The author has devised a new double-probe method to investigate the microwave gas discharge. In this method, the electrodes of the cavity themselves can be used as probes. Brown's theory of the microwave discharge has been applied to this method and a good agreement between theory and experiment has been found. A.

537.525.8

6181. Nitrogen afterglow in a magnetic field. W. R. Kane and K. C. Clark. *J. chem. Phys.*, **23**, *No.* 5, 859–60 (*May*, 1955).

The effect of a magnetic field on the simple exponential decay of a nitrogen afterglow at 0·017 mm pressure is reported. During the afterglow a magnetic field of 850 gauss parallel to the tube axis was alternately present and absent in 95 successive tests; the effect of the field was to slow the decay rate of 0·061 millisecond, as recorded by photomultiplier and oscillograph, by $2{\cdot}9 \pm 0{\cdot}5\%$. Kinetic theory calculations of the effect, based on plausible assumptions concerning ambipolar diffusion, thermalization of electrons and electron attachment, are in approximate agreement with the observation, if one considers that ionic recombination provides much of the excitation energy for this short afterglow. An absence of the magnetic effect would be expected if ions played no rôle in optical excitation. A.

537.525.8 : 535.33.03

6182. Electron groups in the helium negative glow. D. H. Pringle and W. E. J. Farvis. Letter in *Phys. Rev.*, **96**, *No.* 2, 536–8 (*Oct.* 15, 1954).

Screened probes were used to study the three distinct electron groups found in the negative glow region of abnormal glows in helium. The interpretation of these groups is discussed and suggestions are made to account for the slow groups. Axial variations in the intensity of the 3 889 Å line as measured spectroscopically and as deduced from probe data were in agreement. J. D. CRAGGS

537.525.8 : 537.525.5

6183. An evaluation of plasma-ion temperature. O. Shimada. Note in *J. Phys. Soc. Japan*, **9**, *No.* 5, 874–6 (*Sept.–Oct.*, 1954).

Temperature measurements were made on 3 mm Hg pressure argon discharges, excited at 172 cm wavelength. A table is given, comprising measurements of electron temperatures (~20 000°K), ion temperatures

(~2 000°K) and ion density (~5×10^{10}/cm^3), etc., made by a double probe and a microwave technique. J. D. CRAGGS

537.525.8 : 538.561

6184. Microwave and metre wave radiation from the positive column of a gas discharge. L. W. DAVIES AND E. COWCHER. *Austral. J. Phys.*, **8**, *No.* 1, 108–28 (*March*, 1955).

Experiments are described in which the intensity of radio-frequency "noise" radiation from the positive column of low-pressure discharges in neon was measured at 3 000 Mc/s and at 200 Mc/s. Measurements were made by inserting the positive column in a resonant cavity and comparing the cavity output with that from a noise generator of known intensity; corrections were made for contributions to the noise radiation from dissipative elements in the cavity at room temperature. The mean energy of the electrons in the discharge was calculated from measured values of the electric field. As the discharge current was lowered the noise temperature T' at 3 000 Mc/s increased above the calculated value of the electron temperature for an assumed Maxwellian distribution of electron velocities; this phenomenon indicated a change in the distribution function as the electron density was reduced. The thermal level of noise radiation from a plasma with Druyvesteyn distribution of electron velocities was calculated and compared with results for low values of the discharge current. For high values of the current there was good agreement between the values of T' at 3 000 Mc/s and the electron temperature only when the pressure was sufficiently high; for lower pressures T' was less than the electron temperature. In a limited range of discharge conditions the measured values of T' at 200 Mc/s were considerably greater than the thermal level. Experiments were carried out to ascertain the source of this enhanced radiation. A.

537.525.8 : 541.126

Reactions of nitrogen activated by electric discharge. *See Abstr.* 6568

537.525.8 : 621.385.12

6185. Activated cold cathodes for gas tubes. C. BIGUENET. *Vide*, **9**, 266–8 (*Nov.*, 1954) In French.

A brief discussion of the Townsend breakdown condition and of the preparation and properties of cathode surface composed of Ba–BaO complexes. Data for Ne–He–A gas mixtures are given. For example, the breakdown voltages in comparable conditions for Fe and Ba–BaO cathodes were 190 and 72–76. J. D. CRAGGS (R)

537.527.5

6186. The continuum of very high pressure mercury arcs. W. GÖING, H. MEIER AND H. MEINEN. *Z. Phys.*, **140**, *No.* 4, 376–93 (1955) In German.

Describes new and detailed measurements of spectral variations in light intensity (in the lines and the continuous background) for the emitted radiation from an HBO 200 mercury arc (wavelength range about 2 800–6 500 Å). The optical method is described. The results enable the Unsöld formula for the continuum to be compared with experimental data and the agreement is better than in certain previous work. Temperatures and "effective ionization potentials" are also obtained. J. D. CRAGGS

537.527.5

6187. The cross-section and "collecting efficiency" of a potential shell in a particle stream. K. WESTPFAHL. *Z. Phys.*, **140**, *No.* 4, 414–31 (1955) In German.

A contribution to the theory of collisions between atoms in conditions, for example, relevant to high-pressure mercury arc plasmas. According to earlier work by Finkelnburg, Rössler and others, continuous emission may in certain discharges arise from the formation of "stoss"-molecules in atom–atom collisions. The present paper is a consideration of such collision effects, starting with the interaction of a particle with a model potential shell. J. D. CRAGGS

537.529

6188. Contemporary state of the theory of electrical breakdown of solid dielectrics. V. A. CHUENKOV. *Uspekhi fiz. Nauk*, **54**, *No.* 2, 185–230 (1954) In Russian.

A general review article with some 70 references of which half are to Russian literature. Existing theories break down into two groups—theories of breakdown of electric strength, theories of mechanical disruption of the dielectric—neither giving a full description of the development of a breakdown. Theories of the first stage have been developed in great detail, and for the second stage almost not at all. The most up-to-date approaches to a theory of the first stage involve: calculation of effective ionization cross-section in a solid for ionizing electrons of small energy, calculation of probability of scattering of slow electrons on the lattice vibrations, calculation of effective recombination cross-section. Further development of theory of electrical breakdown requires the solution of a series of general problems in solid state theory. The disruption of a dielectric on breakdown is normally considered separately from the first stage and is not linked with the conditions for the passage of an electron avalanche in the solid. The author considers this unjustified, for conceivably these conditions give rise to a shock wave which will generate gases at high pressure. C. R. S. MANDERS

537.529

6189. Phenomenological theory of Townsend breakdown in dielectrics. P. L. AUER. *Phys. Rev.*, **98**, *No.* 2, 320–7 (*April* 15, 1955).

The Townsend model of dielectric breakdown is discussed. The transient equations describing the behaviour of the electron and positive ion current densities are solved rigorously with boundary conditions appropriate to a simplified Townsend model employing photoelectron production at the cathode as the only secondary mechanism. The correct boundary condition is found to lead to a set of integro-difference equations. Solution of the integro-difference equations allows rigorous specification of the criterion for breakdown. This criterion is found to become equivalent to the familiar Townsend criterion in the asymptotic limit of large time intervals. The results of this development may be applied to the calculation of formative time lags and to the estimation of space-charge distortion effects. A.

X-RAYS 537.531

537.531

6190. Intensification and resolution improvement by means of X-ray intensifying screens. C. KLETT. Note in *Naturwissenschaften*, **42**, *No.* 5, 121–2 (1955) In German.

The effect of $CaWO_4$ phosphor screen thickness and with back or front foils on the X-ray image brightness and resolution is studied. Increase in phosphor thickness decreases resolution but with front foil only gives an increase in brightness. G. F. J. GARLICK

537.531 : 535.33

6191. Contribution to the study of the satellite band intensity of the $L\alpha$ lines for elements of atomic number 73 to 92. J. GOMES FERREIRA. *Rev. Fac. Ciênc. Univ. Lisboa B*, **3**, 65–140 (1954) In Portuguese.

The influence of the Auger effect, and atomic number, on the line-width and relative intensity of satellite bands are discussed, considering the Coster and Kronig theory that L satellites are due to double ionization by the Auger effect, with experimental work on the elements from atomic number 30 to 72. The detailed description of the construction and function of the apparatus, includes a possibly new method of preparing microdensitygrams using a photometric wedge. The preparation of each anticathode, sometimes original, their conditions of operation, and the technique of setting the curved (Cauchois) mica crystal, are described. The natural graininess of the photographs was reduced by developing slowly at a low temperature. The microdensity gram for Os is studied in detail, with diagrams, results for the other elements being tabulated. The intensity of the higher frequency $L\alpha_1$ satellite band as a fraction of the $L\alpha_2$ line intensity, rises steadily from 15% for Ta, to 64% for Tl, dropping to 40% for Bi, then decreasing slowly to 36% for U. The lower frequency satellite band gives a similar curve. Hitherto unmeasured $L\alpha_2$ line widths are given for elements from 73 to 83 inclusive, and for Th. Relative intensities of the $L\alpha_1$ and $L\alpha_2$ lines for Pt, Th and Au agree with previous determinations; that for Re is also given.

J. J. PHIPPS

537.531 : 535.33

6192. Effect of background intensity on the position of an X-ray spectrum line. A. N. NIGAM. Letter in *Sci. and Culture*, **20**, *No.* 9, 445–6 (*March*, 1955).

The shift in the maximum is calculated on the assumption of a linearly-varying background and a line profile for which intensity $\propto [(x/b)^2 + 1]^{-1}$.

A. R. STOKES

537.531 : 535.343

6193. Relative intensities of the X-ray K lines of heavier elements. O. BECKMAN. *Ark. Fys.*, **9**, *Paper* 32, 495–529 (1955).

A 2·5 metre focusing curved crystal X-ray spectrometer of the transmitting type is described. The spectrometer is designed for the wavelength region 100–220 X.U., using the $22\bar{4}3$ plane of quartz. The X-radiation has been registered by a scintillation counter with a NaI(Tl) crystal and a single channel discriminator. A stabilized 800 kV van de Graaff generator was used as the high-voltage source. The X-ray K-spectra have been obtained for the elements 73Ta–83Ba, 90Th and 92U at 500 kV and 60–90 μA. The high luminosity of the spectrometer and the low background have made it possible to detect even the weak β_5 and β_4 lines. The intensity ratios between the K lines and the $K\alpha_1$ line have been calculated. Corrections have been made for varying efficiency of the scintillation counter and for X-ray absorption within the target and in the X-ray beam between the target and the counter. The variation of reflecting properties of the crystal with the wavelength has been taken into account. The theoretical calculation of the target absorption has been experimentally verified in the case of gold. The calculated intensities are in general agreement with the theoretically determined values. A slight deviation from the 2 : 1 rule for the intensity ratio of some doublets is observed, however; the mean α_2/α_1 ratio is found to be 0·537 and that for β_3/β_1 is 0·516 for the elements investigated. A weak line resulting from the transition K to L_I has been detected in the spectrum of tungsten and gold. The wavelength is: W KL_I 215·47 ± 0·08 X.U. and Au KL_I 186·33 ± 0·08 X.U. The intensity in each case is 0·2 : 100 relative to that of the α_1 line.

A.

537.531 : 535.343

6194. Effect of chemical combination on the X-ray K-absorption edge of zirconium in its compounds. R. C. KARNATAK. Letter in *J. sci. industr. Res.*, **14B**, *No.* 1, 33–4 (*Jan.*, 1955).

Wavelengths for zirconium and six compounds are given: they range from 687·39 to 686·60 X.U.

A. R. STOKES

537.531 : 535.343

6195. Study of carbon K_α and aluminium $L_{2,3}$ bands by a newly constructed soft X-ray ruled grating spectrograph. K. DAS GUPTA, A. K. SEN AND S. B. BHATTACHARJEE. Letter in *J. sci. industr. Res.*, **14B**, *No.* 3, 129–30 (*March*, 1955).

A soft X-ray vacuum spectrograph with a ruled concave grating of 1 m radius is described. The second and third order of the carbon K_α band are shown. The $L_{2,3}$ band of aluminium at 30°C is also shown. An edge width of 0·22 eV is achieved.

P. T. LANDSBERG

537.531 : 548.733

6196. Absorption and counting-efficiency data for X-ray detectors. J. TAYLOR AND W. PARRISH. *Rev. sci. Instrum.*, **26**, *No.* 4, 367–73 (*April*, 1955).

Mass absorption coefficient data published by Allen, Bragg and by Victoreen [Abstr. 2483 (1950)] for the wavelength region 0·1 to 50 Å are plotted for several common X-ray tube and counter windows (Al, Be and mica) and gases (Xe, Kr, A and Ne) used in X-ray detectors. A graph of the calculated percentage transmission of the windows is presented. The calculated quantum-counting efficiencies for the range 0·1 to 15 Å are shown for an end-window argon-filled Geiger counter, side-window Xe, Kr, A and Ne proportional counters and an NaI·Tl scintillation counter. Some of the factors to be considered in the choice of detectors for X-ray diffractometry and X-ray spectroscopy are discussed particularly with respect to the spectral sensitivity. A.

537.531 : 612.843.6

Visual problems of X-ray image-converters. *See Abstr.* 6667

537.531.08

6197. The use of melamine as an X-radiation detector. M. Birnbaum, J. Schulman and L. Seren *Rev. sci. Instrum.*, **26**, *No.* 5, 457–9 (*May*, 1955).

Melamine, in the form of a clear plastic material, can be used as an X-radiation detector in the range from hundreds to millions of roentgens. The effect of radiation is to increase the optical absorption of melamine for wavelengths from 330 to 480 mμ. The change in absorption produced by the radiation is greater at shorter wavelengths of light. However, in practice a compromise must be realized because the natural absorption of melamine also increases steeply as the wavelength of light is decreased. Preliminary experiments with 11 MeV bremsstrahlung radiation and with Co^{60} γ-rays indicate that the dosimeter properties are roughly independent of the X-ray energy. A.

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533

6198. Experimental investigation of the motions of electrons in a gas in the presence of a magnetic field. B. I. H. Hall. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 6, 334–44 (*June*, 1955).

Results are given of experiments to measure the drift velocities of electrons diffusing in hydrogen under the influence of both electric and magnetic fields. Two cases are considered: (*a*) the magnetic field *B* in the same direction as the electric field *Z*, (*b*) *B* perpendicular to *Z*. The experimental results are interpreted in terms of a convenient microscopic model. A.

537.533 : 621.384.62

6199. Stanford high-energy linear electron accelerator (Mark III). M. Chodorow, E. L. Ginzton, W. W. Hansen, R. L. Kyhl, R. B. Neal and W. K. H. Panofsky. *Rev. sci. Instrum.*, **26**, *No.* 2, 134–204 (*Feb.*, 1955).

A composite paper by the above authors and other members of the Hansen Laboratories staff, Stanford University. The main sections are: basic design features; the accelerating structure; generation and transmission of r.f. power; auxiliary systems; interlock system; beam dynamics; research facilities; radiation shielding; operational results.

537.533.07 : 621.317.729

6200. The determination of electron trajectories in the presence of space charge. D. L. Hollway. *Austral. J. Phys.*, **8**, *No.* 1, 74–89 (*March*, 1955).

The analogy between space charge in an electrostatic field and current sources in an electrolytic tank is considered and methods of simulating clouds of distributed charge by discrete current sources are developed. The field patterns of charge regions of simple geometrical shapes are compared with those of sources and from these results rules are deduced giving the dimensions and arrangement of a source array suitable for any particular problem. Experimental results show these principles applied to a plane diode, an axially symmetric electron beam and a general asymmetric beam. It is concluded that in most problems space charge can be represented adequately in electrolytic models by a comparatively small number of sources. A.

537.533.2

6201. Progress in electron emission at high fields. W. P. Dyke. *Proc. Inst. Radio Engrs*, **43**, *No.* 2, 162–7 (*Feb.*, 1955).

Describes recent advances related to improvements in vacuum technique and circuitry. Emissions of 10^8 A/cm^2 can be obtained with fields of 10^8 V/cm using hemispherical tips of radii 10^{-5}–10^{-4} cm. These are only just resolvable in light microscopes. A razor-edged cathode has yielded an emission of 4 A at 80 kV. Instability is often due to gas contamination or by roughening due to sputtering. Stability is much improved by working at a temperature high enough to keep the surface clean without giving perceptible thermionic emission. It may now be possible to make practical use of the phenomena. A. H. W. Beck

537.533.2

6202. On delayed electron emission from metals. K. Seeger. Note in *Naturwissenschaften*, **42**, *No.* 3, 66 (1955) In German.

Describes experiments on the dependence of the electron emission produced by heating a tungsten foil after it has been bombarded with electrons on the treatment of the surface. J. Dutton

537.533.2

6203. On electron emission from metal surfaces after mechanical treatment. J. Lohff and H. Raether. Note in *Naturwissenschaften*, **42**, *No.* 3, 66–7 (1955) In German.

Describes an experimental investigation of the electron emission and the decay of emission with time *in vacuo* of various metal surfaces after treatment with steel brushes and emery paper. J. Dutton

537.533.2

6204. A contribution to the problem of the emission of exo-electrons from metals. A. Bohun, K. Karpíšková and A. Dušková. Letter in *Czech. J. Phys.*, **5**, *No.* 1, 100–1 (*Feb.*, 1955) In German.

Maxima in the thermoemission of electrons *v.* temperature curve are obtained when copper is irradiated with X-rays and ultraviolet light. It is concluded that the emission arises from the thermal and photodissociation of colour centres in the Cu_2O layer on the surface of the metal. W. Good

537.533.2 : 539.166.83

6205. Electrons emitted from metals after the irradiation by 1·5 MeV X-rays. J. J. Orlin. *Univ. Bergen Arbok*, **1954**, *No.* 9, 14 *pp.*

After irradiation of metals by 1·5 MeV X-rays the emission of electrons was found to be due to the "after effects," except for Ag and Cd which also gave the conversion electrons due to their isomeric states. No conversion electrons due to isomeric states with half-lives between 20 sec and 15 min could be found for the following metals: Mg, Al, Fe, Ni, Cu, Zn, Mo, Pd, Sn, Ta, W, Au and Pb. A.

537.533.33

6206. Exact determination of the cardinal elements of strongly converging lenses. M.-Y. BERNARD. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 15, 1612–14 (*April* 13, 1955) In French.

The cardinal elements of an electron lens combination (strongly converging in one plane and diverging in the plane at right angles) are determined by approximating the true potential distribution to a flat-topped bell-shape which allows exact solution of the electron trajectories. A further simplification involving a rectangular potential distribution is envisaged. A.E.I. RESEARCH LABORATORY

537.533.35

6207. The ring focus in the spiral orbit spectrometer. L. MARQUEZ. *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 5, 785–91 (*May*, 1955).

It is shown that the spiral orbit spectrometer has a ring focus near the stable orbit. Taking advantage of this property by means of a cylindrical slit, the characteristics of this spectrometer can be greatly improved. For a particular case studied, the transmission as a function of the line width is given by $T = 0{\cdot}7W^{\frac{1}{2}}$ for a point source. A.

537.533.73

6208. On the inelastic scattering in electron diffraction. T. ICHINOKAWA AND R. UYEDA. *Proc. Japan Acad.*, **30,** *No.* 9, 857–8 (*Nov.*, 1954).

It is suggested that the diffuse spots in electron diffraction patterns arise from inelastic scattering rather than from thermal vibrations. J. THEWLIS

537.533.74/.75

6209. The effect of multiple scattering on electron energy loss distributions. D. F. HEBBARD AND P. R. WILSON. *Austral. J. Phys.*, **8,** *No.* 1, 90–7 (*March*, 1955).

Calculations have been performed to obtain the theoretical energy loss distributions of 1 MeV electrons traversing foils thick enough for multiple scattering to be important. A criterion has been developed and applied to previous experiments to determine the foil thicknesses for which multiple scattering has an appreciable effect on the energy loss distribution. A.

537.533.74/.75

6210. The energy loss distributions of 1 MeV electrons in aluminium foils. J. A. MCDONELL, M. A. HANSON AND P. R. WILSON. *Austral. J. Phys.*, **8,** *No.* 1, 98–107 (*March*, 1955).

The energy loss distributions for 1 MeV electrons traversing aluminium foils of various thicknesses have been investigated experimentally. Several of the foils were of thicknesses such that the distributions were expected to show considerable effects due to multiple scattering. It was found that the most probable energy losses were in good agreement with those predicted by the calculations of Hebbard and Wilson (preceding abstract). A.

537.533.74

6211. Multiple scattering by the Coulomb field in very thin foils. A. S. KOMPANEETS. *Zh. éksper. teor. Fiz.*, **28,** *No.* 3, 308–11 (1955) In Russian.

Thicknesses in which the number of scatterings is not large compared to unity are considered. A distribution function for scattering more than once is obtained, in which integrals are carried out numerically for optical lengths of material of 1 and 3. This extends previous work to wider angles. In an appendix, an optical model of Coulomb scattering is formulated. G. E. BROWN

537.533.74

6212. High energy electron scattering by beryllium. N. J. PATEL, G. Z. SHAH AND K. M. GATHA. Letter in *Curr. Sci.*, **24,** *No.* 3, 78–9 (*March*, 1955).

Gaussian and uniform nuclear charge distributions appear to fit best the experiments of Hofstadter *et al.* [Abstr. 1389, 8340 (1954)]. G. E. BROWN

537.533.74

6213. Nuclear dispersion contribution to high-energy electron scattering. L. I. SCHIFF. *Phys. Rev.*, **98,** *No.* 3, 756–60 (*May* 1, 1955).

An expression for the contribution of virtual intermediate states of the nucleus (nuclear dispersion) to the elastic and inelastic scattering of high-energy electrons is obtained. The closure relation for the nuclear states is used to put this in a form which depends only on the properties of the initial and final states. An estimate of this contribution in comparison with the first-order scattering shows that it is expected to be small but not negligible for the light elements and somewhat larger for the heavy elements, when the electrons have several hundred MeV energy. The estimate is only valid for large scattering angles. More detailed knowledge of the one- and two-proton transition charge densities would be required in order to extend the range of validity. It seems likely that the bulk of the dispersion correction would be taken into account if the correct electron wavefunctions in the static Coulomb field were to be used in place of plane waves. A.

537.533.74

6214. The multiple scattering of positrons and electrons by nitrogen and argon. N. CUSACK AND P. STOTT. *Phil. Mag.*, **46,** 632–9 (*June*, 1955).

A combination of lens spectrometer and cloud chamber was used to measure and compare the multiple scattering of positrons and electrons at energies in the neighbourhood of 0·4 MeV. The ratio of observed to theoretical mean absolute scattering angle was 0·99 for N_2 and 0·92 for A, with a standard error of 3%. Comparable results by other workers are discussed. In contrast with the conclusions of other workers, no significant difference in the behaviour of positrons and electrons could be detected. A.

537.533.75

6215. Multiple lines in the energy spectrum of electrons passing through an Mg foil. H. WATANABE. Note in *J. Phys. Soc. Japan*, **9,** *No.* 6, 1035–6 (*Nov.–Dec.*, 1954).

Sharp lines were observed, having a separation of ~10·3 eV; thickness of foil was ~600 Å. The possibility of diffraction in MgO film was discounted, and the spectrum ascribed to excitation of undamped plasma oscillation; the energy quantum of such an oscillation in Mg is quoted as 10·8 eV. N. M. KING

537.533.8

6216. Energy distribution of the spectrum of X-ray bremsstrahlung of thin anodes in dependence on atomic number and voltage. H. AMREHN AND H. KULENKAMPFF. *Z. Phys.*, **140**, *No.* 4, 452–64 (1955) In German.

Very soft X-ray bremsstrahlung between 8 and 40 keV was measured with a proportional counter plus amplifier. Measurements were made for Al, Ni and Sn at voltages of 25, 34 and 40 keV. Reasonable agreement with the Sommerfeld theoretical predictions was obtained, although small discrepancies were found for Ni and Sn. G. E. BROWN

537.533.8

6217. A demountable vacuum system for secondary emission studies. A. LEMPICKI. *J. sci. Instrum.*, **32**, *No.* 2, 221–3 (*June*, 1955).

A demountable vacuum system is described in which secondary emission measurements can be carried out without target contamination produced by electron bombardment. This all glass system is free of rubber, grease and wax joints and can be baked at 300–400°C. A.

537.533.8

6218. Distribution in number and energy of particles in electron beams. C. A. D'ANDLAU. *J. Phys. Radium*, **16**, *No.* 3, 176–8 (*March*, 1955) In French.

Measurements were made of the number and energy distributions of electrons produced in lead foils by primary electrons of energies between 50 and 2 500 MeV, using a cloud chamber in a magnetic field. The results correspond to a Poisson distribution. J. FRANKS

537.533.9

6219. Effect of electron bombardment on secondary and photo-electron emission of cesium antimonide. K. MIYAKE. Note in *J. Phys. Soc. Japan*, **10**, *No.* 2, 164–5 (*Feb.*, 1955).

Describes measurements of the change with bombardment time (up to 50 hr) of the secondary electron and photoelectron yield and of the spectral distribution of the photoelectrons for CsSb. The observed fatigue characteristics are believed to be due to the formation of colour centres. E. P. WOHLFARTH

537.533.9

6220. Cherenkov radiation of the space charge in waveguides and in unbounded medium. Č. MUZIKÁŘ. *Czech. J. Phys.*, **5**, *No.* 1, 1–10 (*Feb.*, 1955) In Russian, with summary in English (1 p.).

Formulae are deduced for the electromagnetic field and for the Cherenkov radiation of the space charge acting in a smooth, ideally conducting, waveguide of arbitrary cross-section. Complete solution is given for a waveguide of circular cross-section. With their axes parallel to the direction of motion the relations for the Cherenkov radiation of the electric quadripole acting in an unbounded medium are obtained. Z. F. WOJNAR

537.533.9

6221. Čerenkov radiation of electrons moving parallel to a dielectric boundary. J. G. LINHART. *J. appl. Phys.*, **26**, *No.* 5, 527–33 (*May*, 1955).

The phenomenon is investigated using an eigenfunction expansion of the electromagnetic field. It is shown that the Cherenkov effect is similar to the excitation of surface waves in travelling-wave tubes. A.

537.533.9

6222. Quantum effects in the interaction between electrons and high-frequency fields. II. I. R. SENITZKY. *Phys. Rev.*, **98**, *No.* 4, 875–84 (*May* 15, 1955).

For Pt I, see Abstr. 10259 (1954). The study of the appearance of quantum effects in an essentially classical experiment—involving the passage of an electron through a resonant cavity—as the frequency of the electromagnetic field increases, was begun in Pt I, in which the electron velocity was examined. In the present paper, an analysis is made of the electric field in the same experiment. Both the expectation value of the field, and the expectation value of the square of the deviation from the expectation value (the dispersion) of the field are calculated to the lowest order in the electron charge. The expectation value of the field is seen to differ from the classical value by a small amount, the difference being due to the wave properties of the electron. The dispersion in the field is shown to consist of three parts: One due to the quantum-mechanical properties of the field alone, the second due to the wave properties of the electron, and the third due to the interaction between the quantum-mechanical properties of the field and the classical properties of the electron. The orders of magnitude of the three terms are shown to decrease in the order in which they are enumerated. A calculation is then made of the effect on the field of a number of electrons passing through the cavity, the interaction between the electrons being neglected. The number of electrons required in a "bunch" to produce a field comparable to the dispersion in the field is calculated, and, for a typical set of experimental conditions, it is seen that the highest frequency at which this requirement can be met is of the order of 3×10^{12}/sec. A.

537.533.9 : 538.561 : 621.385.1.029.6

6223. Interaction of moving charges with wave circuits. J. R. PIERCE. *J. appl. Phys.*, **26**, *No.* 5, 627–38 (*May*, 1955).

When a charge moves along a non-dispersive transmission line it induces forward and backward wave components in the line. For unaccelerated motion there is no radiation unless the charge moves with the speed of an unforced wave. For small accelerations, both radiation to the line and electromagnetic inertial effects caused by changes in the energy of the fields will be observed. The electromagnetic mass at velocities greater than the wave velocity is negative. Large accelerations can be handled by numerical computation. In the case of dispersive circuits, the charge radiates at frequencies for which the phase velocity of the circuit is equal to the velocity of the charge. This radiation is identified with Cherenkov radiation. Similar radiation takes place when a charge moves through a plasma. A.

537.534

6224. Production of an intense pulsed deuteron beam. F. PRÉVOT AND R. VIENET. Letter in *J. Phys. Radium*, **16**, *No.* 3, 238 (*March*, 1955) In French.

Describes the ion source used in the Saclay van der

Graaff for time-of-flight studies. Source is at earth potential and consists of a cold-cathode discharge in an axial *H*-field of 200 G, the arc of 1·5 A intensity being pulsed for 20 μsec to reduce background and power dissipation. Extraction voltage is pulsed to 7 kV during 1 μsec, repeating every 260 μsec. Background has been reduced as much as possible, and a 9 mA beam of 1·55 MeV deuterons has been focused at 2·5 m from the source with a background of $<5\mu$A. N. M. KING

537.534

6225. Some proton synchrotron beam studies with the induction electrode. L. RIDDIFORD, H. B. VAN DER RAAY AND R. F. COE. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 6, 489–502 (*June*, 1955).

The principle of the induction electrode and its application to the detection of the circulating proton beam in the Birmingham synchrotron are discussed. Investigations have been made of the phase width of the bunch of protons being accelerated, and of the period of the phase oscillations. These provide a confirmation of the theory of Bohm and Foldy concerning the acceleration process in a synchrotron. A study of the effects of pressure and aperture on the circulating beam shows that the requirements are more stringent than anticipated from the Blachman–Courant theory of gas scattering in such an accelerator. The difference is explainable in terms of characteristics particular to the Birmingham accelerator. A.

537.534

6226. Experimental characteristics of the proton synchrotron. P. B. MOON, L. RIDDIFORD AND J. L. SYMONDS. *Proc. Roy. Soc. A*, **230**, *No.* 1181, 204–15 (*June* 21, 1955).

The Birmingham proton synchrotron is described in relation to its experimental use as a source of high-energy protons. Information is given on matters such as the dimensions and intensity of the circulating beam, the methods by which its impact upon internal targets can be controlled, and the effect of the field of the magnet upon the paths of secondary charged particles. A.

537.534 : 621.384.62

6227. Focusing system for the 600 MeV proton linear accelerator. M. BELL AND W. WALKINSHAW. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T/M*112, 6 *pp.* (1954).

Detailed calculations have been made for the radial motion of the synchronous protons of the 600 MeV linear accelerator. Acceleration up to 10 MeV is obtained with grid focusing presenting a beam estimated to be of 1 cm dia. with a divergence of 0·2°. The phase spread of the protons at 10 MeV is roughly $\pm 15°$ about the stable phase of 30°. The design of the strong-focusing system to be used above 10 MeV is discussed here. It is shown from aperture considerations that the 10 MeV beam will be accelerated without loss with magnetic focusing of the order of 1 500 gauss, at 10 MeV, decreasing roughly inversely with velocity to 50 MeV. At this energy the field has to be increased to 1 500 gauss because of the r.f. wavelength change, but will decrease again at higher energies. A.

537.534.1

6228. Equilibrium charge distribution of energetic nitrogen ions. H. L. REYNOLDS, L. D. WYLY AND A. ZUCKER. *Phys. Rev.*, **98**, *No.* 2, 474–7 (*April* 15, 1955).

The equilibrium charge distribution of nitrogen ions in Formvar was measured as a function of the nitrogen energy from 6 to 26 MeV. The fringing magnetic field of the cyclotron was used to separate the charge groups resulting from the passage of the nitrogen ion beam through Formvar foils of sufficient thickness to insure an equilibrium charge distribution. Over the energy range investigated, the ionic charge is distributed primarily between four, five, six and seven electron charges. The percentage of completely stripped ions varies from 42% at 26 MeV to 6% at 11 MeV. The ratio of the electron loss to capture cross-section between N^{7+} and N^{6+} as well as between N^{6+} and N^{5+} is proportional to $V^{4\cdot0}$, whereas between N^{5+} and N^{4+} the ratio is proportional to $V^{2\cdot9}$. This ratio is unity for N^{6+} and N^{7+} at approximately 28·2 MeV, and for N^{5+} and N^{6+} at 13·3 MeV. A.

537.534.3

6229. Resolving power of the three-grid system of the Bennett-type mass spectrometer. A. PETERLIN. Letter in *Rev. sci. Instrum.*, **26**, *No.* 4, 398–9 (*April*, 1955).

The resolving power of the three-grid system of the Bennett-type of radio-frequency mass spectrometer is calculated for an applied period, i.e. waveform of arbitrary shape. It is shown that if for a given voltage $U = U_0 \sin \omega t$, the resolution has a certain value, then, other things being equal, the resolution of the system can be improved considerably by applying a voltage of the form $U = U_0(\sin \omega t + \mu \sin 2\omega t)$ where μ is a positive or negative constant between ± 1. For negative μ, an increased transmission is also obtained. The most favourable condition is $\mu = -1$, when the resolution relative to the case $\mu = 0$ is improved by a factor 2·24 and the transmission is improved by a factor 2·45. The effect is shown to be even larger for a sawtooth signal. D. R. CHICK

537.534.3

6230. Improved resolving power of the rf mass spectrometer by changing the signal shape. J. DEKLEVA AND A. PETERLIN. Letter in *Rev. sci. Instrum.*, **26**, *No.* 4, 399 (*April*, 1955).

The experimental work which is described follows from some theoretical work by Peterlin which predicts a substantial increase in resolving power by changing the signal shape applied to the grids of a radio-frequency mass spectrometer from a pure sine wave $U = U_0 \sin \omega t$ to $U = U_0(\sin \omega t - \sin 2\omega t)$. The circuit of a signal generator for producing the required waveform is given and results presented which show that an improvement in resolution by a factor of 2·65 can be obtained as compared with the simple sine wave. This is in quite good agreement with the theory for a single stage. D. R. CHICK

537.534.3 : 545.827

Analytical mass spectrometer utilizing modulated ion beams. *See Abstr.* 6597

537.534.72 : 621.317.7.082.72

6231. An electrostatic analyser for the absolute measurement of proton energies and the establishment of fixed points on the high-voltage scale. S. E. HUNT, D. P. R. PETRIE, K. FIRTH AND A. J. TROTT. *Proc. Instn Elect. Engrs, Paper No.* 1840 M, publ. *May*, 1955, 6 *pp*. [To be republished in **103 B** (1956).]

An electrostatic analyser for measuring the energy of proton beams from an electrostatic generator is described. The energy measurements are absolute and are referred finally to the voltage of thermostatically controlled standard cells. The angle of deflection, 63·2°, was chosen to focus a parallel incident beam on to a fine exit slit. Target currents of over 20μA were thus obtained with an energy resolution of 1 200. The energy of a proton beam producing the lowest strong resonance in the $F^{19}(p\alpha\gamma)O^{16}$ reaction was determined as 874·5 ± 0·9 keV (absolute); the width of the resonance at half maximum yield was 5·0 ± 1·0 keV. Resonance in the $Be^{9}(p\gamma)B^{10}$ reaction were found for proton energies of 2·567 ± 0·003 MeV, 1·083 7 ± 0·000 7 MeV and 989·5 ± 1·4 keV. The widths at half-maximum yield of these resonances were 41 ± 3 keV, 3·8 ± 0·3 keV and 91 ± 5 keV respectively. A.

537.534.74

6232. Differential cross-section measurements for large-angle collisions of helium, neon, and argon ions with argon atoms at energies to 100 keV. E. EVERHART, R. J. CARBONE AND G. STONE. *Phys. Rev.*, **98**, *No.* 4, 1045–9 (*May* 15, 1955).

The differential cross-section for the scattering of positive charge from collisions of noble gas ions with the target gas argon has been measured. The ion beam is passed through a chamber containing the target gas at a pressure of a few microns of mercury, which is low enough to insure that single collisions will predominate. The particles scattered out of the beam are collected and the total positive charge is measured. The collector incorporates collimating holes to select only those particles at a chosen scattering angle with a resolution of about two degrees. The apparatus allows the angle to be varied continuously up to thirty-eight degrees. Data are presented for collisions of singly ionized helium, neon and argon ions with argon atoms at 25, 50 and 100 keV. The cross-sections observed differ from those expected from the Rutherford scattering law and these differences are interpreted in terms of electron screening, ionization and charge exchange. A.

537.534.74

6233. Measurements on multiple scattering of stopping particles. R. G. GLASSER. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 385–8 (1954).

From measurements on 100 stopping protons giving tracks longer than 3 000 μ, from the Chicago synchrocyclotron, a relationship between range and multiple scattering has been derived. It differs significantly from that obtained by combining the best semi-empirical range–energy relation with the assumption that the scattering constant is always equal to 25. The validity of the empirical relation has been checked by measurements on 20 stopping π^{+}-mesons. P. ROTHWELL

537.534.74

6234. A phase shift analysis of the scattering and polarization in proton-proton collisions at high energy. C. A. KLEIN. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 581–9 (*April*, 1955) In French.

Experimental evidence on scattering and polarization in the 100–400 MeV range is analysed in terms of the *S*- and *P*-wave phase shifts. P. T. MATTHEWS

537.534.74

6235. *S* and *P* wave analysis of proton-proton scattering experiments. L. BERETTA, E. CLEMENTEL AND C. VILLI. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 739–41 (*April*, 1955).

A method is described for determining the *S*- and *P*-wave nuclear phase shifts from the Coulomb interference. P. T. MATTHEWS

537.534.74

6236. Rotation of polarization vector and depolarization in *p–p* scattering. T. YPSILANTIS, C. WIEGAND, R. TRIPP, E. SEGRÈ AND O. CHAMBERLAIN. Letter in *Phys. Rev.*, **98**, *No.* 3, 840–2 (*May* 1, 1955).

A 310 MeV, 0·74 polarized, proton beam is scattered by a liquid hydrogen target and rescattered by a carbon analysing target. Results are reported of the measurement of the angular dependence of the depolarization and rotation parameter. The information is sufficient to determine the phase shifts up to and including those for *F*-waves. P. T. MATTHEWS

537.534.74 : 539.185

6237. Polarization of fast protons and neutrons. I. I. LEVINTOV. *Uspekhi fiz. Nauk*, **54**, *No.* 2, 285–314 (1954) In Russian.

A review article mainly based on fourteen papers which have appeared in *Phys. Rev.* since 1949 dealing with polarization by scattering, elastic scattering of uncharged particles with zero spin, scattering of non-polarized uncharged particles with spin $\frac{1}{2}$ on a nucleus with spin zero, axial asymmetry during scattering of polarized particles with spin $\frac{1}{2}$ on particles of zero spin. C. R. S. MANDERS

537.534.75

6238. Range-energy relation of tritons in the nuclear emulsion up to 10 MeV. M. MIWA AND K. KURIYAMA. Note in *J. Phys. Soc. Japan*, **10**, *No.* 4, 320–1 (*April*, 1955).

Alpha-particle–triton pairs have been observed in lithium loaded Ilford E1 nuclear emulsion from the reaction $Li^{7}(\gamma,t)He^{4}$. The emulsions were exposed to the bremsstrahlung X-rays from a betatron. Only particles emitted normally to the incident photon beam were measured. A graph of triton range against α-particle range was plotted and from the kinematics of the reaction and the known range-energy relation for α-particles, the relation for tritons up to 10 MeV was constructed. A slight discrepancy ($\simeq$10%) was noticed between this relation and that calculated from the proton relation. The humidity conditions at the time of exposure are not mentioned. D. J. PROWSE

537.534.79

6239. Loss of electrons from fast nitrogen ions in collisions with single gas molecules. K. G. STEPHENS AND D. WALKER. Letter in *Phil. Mag.*, **46**, 563–6 (*May*, 1955).

The cross-section for electron loss is investigated for

N^{2+} ions accelerated to 15 MeV ($1{\cdot}43\times10^{9}$ cm/sec) in the Birmingham cyclotron. It is found to have an absolute value of about 4×10^{-16} cm^2 in air and the electron capture cross-section is found to be not more than ½% of this. It is also shown that in most cases a single electron is lost but that in between ¼ and ¾ of the cases two are lost simultaneously. J. H. FREMLIN

DISCHARGE TUBES . COUNTERS 537.54

537.542

6240. Basic characteristics of ionization chambers. N. I. Shteĭnbok. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11), 615–25 (1954) In Russian.

A new expression is derived for the voltampere characteristic of ionization chambers for the case where there is absence of diffusion of ions and where space charge influence can be neglected. The validity of the expression was confirmed in experiments with a plane ionization chamber. The expression derived for the plane chamber does not involve dimensions and so should be valid for any type of chamber. In calculating the initial resistance R_0 (i.e. that given by the first, straight-line part of the voltamp. characteristic) for various shapes of chamber it is necessary to make use of the well-known formulae for transition from the plane to other shapes of chamber. The author derives a simple relationship $I_\infty R_0^2 = \Omega$, where I_∞ represents saturation current, R_0 as above, and Ω is a constant. There are grounds for suggesting that this is an expression of general validity for ionization chambers. Although data in Anglintsev's book *Dosimetry of ionizing radiations* (State Tech. Press, 1949) bear out the above expression, the author agrees that further testing is required. An expression is also derived which may prove of use in calculations and studies on ionization chambers, viz. $U = \sqrt{\Omega}\sqrt{I_\infty}(R/R_0)$ where U represents tension to be applied to the chamber for a given degree of saturation (R/R_0). C. R. S. MANDERS

537.542

6241. A–N_2 fillings make ion chambers insensitive to O_2 contamination. U. Facchini and A. Malvicini. *Nucleonics*, **13**, *No.* 4, 36–7 (*April*, 1955).

Chambers containing mixtures of A with 2–4% N_2 give good counting characteristics with up to ½% O_2 present. The mixture keeps the electron energies at 1 eV, where the cross-section for electron capture by O_2 is a minimum. L. R. SHEPHERD

537.542

6242. A self-quenching light counter. S. F. Rodionov, M. S. Khaĭkin and A. I. Shal'nikov. *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 223–7 (1955) In Russian.

The construction of a sensitive self-quenching photon counter is described possessing very stable properties and suitable for mass-production. A method is explained for determining the sensitivity of such counters, special attention being given to evaluating the spectral distribution of the light source used. Curves are given for the spectral sensitivity of counters containing a mixture of 85% argon and 15% methylal vapour, for photocathodes made of platinum, aluminium and magnesium. A typical counter characteristic is also given together with the dark count for a counter of given dimensions.

V. V. ZAKHAROV

537.542

6243. Adding circuits. M. Cervasi and G. Fidecaro. Note in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 942–8 (*May*, 1955) In Italian.

Two types of adding circuits used in a cosmic-ray experiment in connection with a large G.M. counter hodoscope are described. Precision and long range stability of the output pulses are discussed. In one of the two circuits, the operating conditions of the pulse-shaping tubes are rather unusual. As a consequence of the very low plate voltages used, the tubes exhibit a negative transconductance over a certain range of control grid voltages. This effect and its influence on the stability of the circuit are also discussed. A.

537.542

6244. Apparatus for measuring the intensity of cosmic radiation at great depths in the sea. J. C. Barton. *J. sci. Instrum.*, **32**, *No.* 6, 226–9 (*June*, 1955).

A portable cosmic-ray equipment and an aluminium alloy pressure vessel in which it can be enclosed are described. The apparatus consists of a three-fold coincidence arrangement of Geiger–Müller counters operated entirely from dry batteries. The total power consumption is about ¼ W and one set of batteries is sufficient for a week's continuous operation. A small portable scaler which can be used in conjunction with this apparatus is also described. A.

537.542

6245. X-ray beam measurement of distortion in a magnet cloud chamber. R. M. Walker. Note in *Rev. sci. Instrum.*, **26**, *No.* 3, 304–5 (*March*, 1955).

The circuit is given for pulsing an X-ray tube with a variable injection time, useful for measuring chamber sensitive time. Typical photographs are given of the X-ray beam in argon and helium, in the latter gas without a magnetic field, the track was very uneven and the precision of locating its centre less than with a field of 8 200 gauss applied. J. HUGHES

537.542

6246. Remarks on the operation of the diffusion cloud chamber. I. P. E. Argan, N. D'Angelo and A. Gigli. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 761–84 (*May*, 1955).

A theoretical study has been carried out on a diffusion cloud chamber operating with methyl-alcohol vapour in air at normal pressure, and with a strong temperature gradient. Temperature distribution, vapour pressure and supersaturation have been calculated as functions of the number of ions formed per cm^3 per sec in the interior of the chamber. The calculated height of the sensitive layer is consistent with the experimental observations. The study has been extended to the case in which the various quantities depend on both vertical and horizontal coordinates. Information has been obtained about the perturbation of the structure of the sensitive layer as the result of introducing plates inside the chamber with

a certain temperature distribution; in particular the approximate distance from these plates (or from the side walls of the chamber) at which tracks of ionizing particles are still observable has been determined. A.

537.542

6247. Cloud chamber and associated techniques. E. H. S. BURHOP. *Nature* [*London*] **175,** 832–3 (*May* 14, 1955).

Brief report of a conference, held in the Physics Department, University College, London, March, 1955, on the relative merits of these methods of particle track detection and their respective fields of applicability.

537.543 : 621.385.2

6248. Noise at the potential minimum in the high-frequency diode. D. A. WATKINS. *J. appl. Phys.*, **26,** *No.* 5, 622–4 (*May*, 1955).

Noise quantities at the potential minimum in the high-frequency diode are analysed by means of a relatively simple model which assumes that the transit angle from the cathode to the potential minimum is small and that the transit angle from the potential minimum to the anode is large. The mean-square convection current is found to be about half full shot-noise for a typical case and the mean-square velocity is found to be the same as in the temperature-limited case. Application of this result to an analysis of the minimum obtainable noise figure of klystrons and travelling-wave tubes using velocity-jump noise reduction shows that their noise figure can be reduced without theoretical limit by increasing the current density at the cathode. A.

IONIZATION . THERMIONICS 537.56/.58

537.56 : 523.877

6249. The influence of ionic interaction on the equilibrium concentration for the case of multiply thermally ionized gas. B. L. TIMAN. *Zh. éksper. teor. Fiz.*, **27,** *No.* 6(12), 708–11 (1954) In Russian.

By the application of the Debye–Hückel theory it is shown that the interaction between the ions has a considerable effect on the equilibrium under conditions to be found in stars. J. M. HOUGH

537.561 : 539.132

6250. Ionization potentials and electron affinities of conjugated hydrocarbon molecules and radicals. N. S. HUSH AND J. A. POPLE. *Trans Faraday Soc.*, **51,** *Pt* 5, 600–5 (*May*, 1955).

The self-consistent molecular orbital theory with systematic approximation for electron interaction integrals is applied to the calculation of the ionization potential I and the electron affinity A of alternant conjugated hydrocarbon molecules and radicals. The theory predicts the simple result $I + A = \text{const.}$ for all such molecules and radicals. Calculations have been made for a series of molecules and radicals using semi-empirical values of electron interaction integrals proposed by Pariser and Parr. The agreement with experimental data is satisfactory. In particular, it is shown that certain features of the experimental results cannot be understood unless electron interaction is taken into account explicitly. A.

537.562

6251. High-frequency ionization coefficients in neon–argon mixtures. A. D. MACDONALD AND J. H. MATTHEWS. *Phys. Rev.*, **98,** *No.* 4, 1070–3 (*May* 15, 1955).

Breakdown electric fields at 2 800 Mc/s frequency are presented for a number of neon–argon mixtures for a large range of pressure variation. High-frequency ionization coefficients for mixtures varying from pure neon to pure argon have been computed from the breakdown fields. The collision phenomena in the gas mixtures are discussed and a theoretical derivation of breakdown fields is compared with experiment. A.

537.564

6252. Cross sections for 2*s*–2*p* transitions in H and 3*s*–3*p* transitions in Na produced by electron and by proton impact. M. J. SEATON. *Proc. Phys. Soc.* [*London*] *A*, **68,** *Pt* 6, 457–73 (*June*, 1955).

Reliable cross-sections for 2*s*–2*p* transitions in H produced by electron and by proton impact are required in certain astrophysical problems. In calculating these cross-sections it is necessary to allow for strong coupling effects. Such effects are also important for 3*s*–3*p* transitions in Na produced by electron impact, for which experimental results are available. The total cross-section Q is the sum of components Q^l arising from the components of the incident wave with angular momenta $\hbar[l(l+1)]^{1/2}$. For these a limiting value $Q^l_{\max}$ is set by the requirement of charge conservation. The approximation adopted is to calculate the Q^l using the Bethe approximation, to accept the values obtained if $Q^l_{\text{Bethe}} < \frac{1}{2}Q^l_{\max}$ and to put $Q^l = \frac{1}{2}Q^l_{\max}$ if $Q^l_{\text{Bethe}} \geqslant \frac{1}{2}Q^l_{\max}$. The conditions for the validity of this approximation are examined, some use being made of an exactly soluble schematic model. It is considered that the final results for the H transitions should be correct to within $\pm 20\%$. The results obtained for electron collisions with Na are found to be in good agreement with experiment, the approximation used being considerably superior to the Born approximation at low energies. A.

537.564

6253. The growth of an electron avalanche retarded by its own space charge. G. FRANCIS. *Proc. Phys. Soc.* [*London*] *B*, **68,** *Pt* 6, 369–80 (*June*, 1955).

Calculations are given showing how the ionization coefficient α, and the total multiplication in the avalanche, vary with the distance travelled when the positive ions formed have an appreciable effect. The time taken for an avalanche to develop is also worked out. Plane parallel geometry is considered, and two important cases are treated, namely, constant field at the electrodes, or constant potential across them. A simple and exact solution is obtained for constant field, and an approximate solution for constant potential. The latter shows that α may decrease or increase depending on the initial conditions, and that it tends finally to a constant value. The equations are general and thought to be of wide application. A.

537.567

6254. Experimental cross section for photodetachment of electrons from H^- and D^-. L. M. Branscomb and S. J. Smith. *Phys. Rev.*, **98**, *No.* 4, 1028–34 (*May* 15, 1955).

The photodetachment of electrons from atomic hydrogen negative ions has been studied, and the integrated cross-section measured by using the radiation from a tungsten filament at 3300°K in a modulated crossed-beam experiment. The wavelength dependence of the cross-section is measured from 4000 to about 9000 Å by using sharp-cut glass filters. The ratio of the experimental integrated cross-section to the value predicted theoretically by Chandrasekhar is 1·01, with a 2% reproducibility and 10% upper limit to the systematic errors. A.

537.568

6255. Charge transfer and ion-atom interchange collisions. D. R. Bates. Note in *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 344–5 (*April*, 1955).

Consideration of the conversion of atomic ions into molecular ions in collisions with neutral molecules. It is shown that straightforward charge transfer (exothermic) will be very inefficient at thermal energies, whereas the rate-coefficient for ion-atom interchange of the form $X^+ + YZ \rightarrow XY^+ + Z$ may be quite large in certain cases. These results are important in the interpretation of experimental results and in theoretical studies of the ionosphere.

G. M. BROWN

537.581

6256. Velocity analysis of thermionic emission from single-crystal tungsten. A. R. Hutson. *Phys. Rev.*, **98**, *No.* 4, 889–90 (*May* 15, 1955).

A 180° magnetic velocity analyser tube has been used to observe the energy distributions of the thermionic emission from various crystallographic directions of a single-crystal tungsten filament. The distributions were the same in all of the directions and were not Maxwellian. An energy-dependent reflection coefficient for the tungsten surface, previously proposed by Nottingham, is capable of explaining the shape of the distributions quite well. The tube permitted measurements of the differences between the true work-functions of the various directions. The changes of true work-functions with temperature between 1700 and 2000°K were also measured for all directions except the (110). The non-Maxwellian character of the energy distributions and the temperature variations of the work-functions can largely explain the discrepancy between the emission constant, $A = 120$, of Richardson's equation and the Richardson-plot emission constants obtained for the various directions of a tungsten crystal by Nichols and by Smith. A.

537.582

6257. Relation between electrical conductivity and electron emission and the energy of a metal heated by a current of high density. L. N. Borodovskaya and S. V. Lebedev. *Zh. éksper. teor. Fiz.*, **28**, *No.* 1, 96–110 (1955) In Russian.

At a current density $6\times10^4 \lesssim I \lesssim 5\times10^6$ A/cm² the relation $R = R(E)$ for nickel is the same as for tungsten, viz. the curve of the temperature relation has a bend below which the function $R(E)$ is independent of I, whereas it varies with I above the bend; the energy $E(t_c)$ at which R rises steeply decreases with decreasing I. At the bend in the curve $R = R(E)$ the energies and resistances correspond to the melting point of the metal in normal conditions. The electron emission of a nickel wire heated by a current pulse of 10^5 A/cm² equals 50× the emission of nickel at the melting point, without disintegration of the wire. The emission of nickel and tungsten falls when the energy supply of the wire exceeds many times the energy losses measured in steady high-vacuum annealing of the wire to melting point. Data were also obtained on the rate of decrease of the emission after disconnection of the heating current.

B. F. KRAUS

537.583

6258. On the electron bombardment effect for deposited barium oxide films. II. T. Imai and Y. Mizushima. Note in *J. Phys. Soc. Japan*, **9**, *No.* 6, 1032–4 (*Nov.–Dec.*, 1954).

A continuation of previous work [Abstr. 4653 (1954)]. Activation and de-activation effects of electron emission from cathodes of barium oxide deposited on Pt and Ta sleeves which follow electron bombardment and heating is ascribed to the presence of free barium produced by the dissociation of the oxide. C. G. MORGAN

COSMIC RAYS 537.591

537.591

6259. Report on the expedition to Sardinia, 1953. J. Davies and C. Franzinetti. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 480–97 (1954).

Gives technical details of the equipment used, including balloon performances, and of the organization of the flights. Flight records and altimetric profiles of the successful flights are also provided.

P. ROTHWELL

537.591.1

6260. Results of limitations on space current densities in galactic and intergalactic space. W. F. G. Swann. *Phys. Rev.*, **98**, *No.* 4, 871–5 (*May* 15, 1955).

The accepted view as to the very high electrical conductivity of space has raised difficulties in mechanisms concerning the production of cosmic-ray energies. It is to be observed that high conductivity does not avoid the existence of a saturation on current density, i, which is equal to nec, where n is the sum of the numbers of positive and negative ions per cm³. Thus for $n = 1$, the saturation current density is of the order 5×10^{-9} A/cm². The effect of saturation is illustrated by the following idealized conditions: Consider two coplanar rings of gas A and B, A being smaller. Under conditions of very high conductivity, it would be impossible for the magnetic flux through either circuit to change and the electric field would be zero. If B expands, the flux through A due to B will change, but the total

flux through A will not change if A has high conductivity. A will acquire induced current to compensate the change of flux arising from B. However, as time proceeds, and if the ionic density in A is small, a stage will be reached at which A can no longer develop the current necessary for magnetic flux compensation. An electric field will now arise in A and the ions will become accelerated to cosmic-ray energies, not by appreciable alteration of velocity which has already attained its maximum c, but by alteration of relativistic mass. A.

537.591.1

6261. On the transition effect of cosmic ray neutrons in the atmosphere. P. MEYER. *Z. Phys.*, **141**, *No.* 1–2, 28–32 (1955) In German.

Height–intensity curves have been determined for different neutron mean energies by means of balloon flights employing BF_3 counters and Cd or B_4C absorbers, thus registering energies of 0·4 eV or >1 keV. The maximum of the curves is displaced towards greater heights with increasing neutron energy in accordance with theory and, for the highest energy range measured, is similar to that in the burst curve measured by means of ionization chambers.

E. W. KELLERMANN

537.591.1

6262. The relation between cosmic-ray intensities and heights of isobar levels. II. On the positive temperature effect. M. WADA AND S. KUDO. *J. Sci. Res. Inst.* [*Tokyo*] **48**, 245–59 (*Dec.*, 1954).

For Pt I, see Abstr. 9573 (1951). The positive relation between the intensity of cosmic-rays observed at sea level and the temperature at around 100 mb level is investigated. Existence of this relation and several suggestions such as those proposed by Trefall and Olbert for the interpretation of it are verified. The latter are, however, not enough for thorough explanation of the relation. Some remarks on ordinary barometer and temperature effects are also described. A.

537.591.1

6263. The energy spectrum of cosmic-ray protons at sea level. H. FILTHUTH. *Z. Naturforsch.*, **10a**, *No.* 3, 219–29 (1955) In German.

18 to 350 MeV protons contained in the vertical cosmic-ray beam have been examined using a telescope arrangement consisting essentially of proportional counters and other means to differentiate against the effects of mesons and electrons. The proton energies were determined from range measurements and result in a spectrum with a maximum between 80 and 100 MeV. Its decrease towards higher energies fits the results of M. G. Mylroi and J. G. Wilson [Abstr. 5518 (1951)] at the lower end of their range. The vertical proton flux in the examined range is $0{\cdot}56 \times 10^{-4}/\text{cm}^2$. sec steradian.

E. W. KELLERMANN

537.591.1

6264. Momentum spectrum and positive excess of cosmic ray particles at 3 650 m altitude under 15 cm lead. J. BECKER, P. CHANSON, E. NAGEOTTE AND P. TREILLE. *J. Phys. Radium*, **16**, *No.* 3, 191–9 (*March*, 1955) In French.

The experiments have been made using a cloud chamber in a magnetic field. It is found that between 2 and 30 BeV/c the differential spectrum has an exponent −1·9 for the positive particles and −1·8 for the negatives. The positive excess therefore decreases with increasing momentum. Between 0·4 and 0·8 BeV/c the proportion of protons is (11 ± 1)%.

H. ELLIOT

537.591.1 : 530.12

Relativistic transformations and conservation of energy and momentum applied to cosmic rays (review). *See Abstr.* 5857

537.591.15

6265. Penetrating showers in H and C. P. COLOMBINO, S. FERRONI AND G. WATAGHIN. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 340–1 (1954) In Italian.

The results of a new series of measurements on penetrating showers generated in layers of paraffin and graphite at 3 500 m are reported. Analysis of events produced by protons and by neutrons reveals a difference between neutron–proton and proton–proton cross-sections. The barometric effect is 17% per cm Hg for dense showers, and 7% for showers generated by the nucleonic component in the absorber.

P. ROTHWELL

537.591.15

6266. On the composition and properties of shower particles produced in high-energy interactions. D. LAL, Y. PAL AND RAMA. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 347–52 (1954).

Seventy-nine high-energy interactions have been examined. In particular, the interactions of the shower particles and the frequency of production of π^0-mesons have been studied. The interaction mean free path is substantially geometric; the value of N_h in the secondary interactions is only about 3–4. The ratio N_{π^0}/N_s is 0·40 ± 0·08 in agreement with the results of other workers. P. ROTHWELL

537.591.15

6267. On a star with more than 200 shower particles. M. TEUCHER. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 361–3 (1954).

Considers the angular distribution of the 221 shower particles created in the collision of an oxygen nucleus with an Ag or Br nucleus. The primary energy is estimated to be ~70 GeV/nucleon. The very large multiplicity is not explicable either by the theory of Fermi or by that of Heisenberg, and it is suggested that there might be a much larger energy dissipation in the collision of two heavy nuclei.

P. ROTHWELL

537.591.15

6268. On the observation of Cherenkov radiation, accompanying wide atmospheric showers of cosmic rays. N. M. NESTEROVA AND A. E. CHUDAKOV. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 384 (1955) In Russian.

Cherenkov radiation is measured with a parabolic mirror and photomultiplier at 3 860 m on dark nights, and correlated with wide air showers registered by counters. Correlation is a few per cent. A low figure is to be expected because wide air showers with axis up to ~250 m distant register on the former, whereas only up to ~50 m on the latter.

G. E. BROWN

537.591.15

6269. Observations on the penetrating component of extensive air showers. V. C. Officer and P. J. Eccles. *Austral. J. Phys.*, **8**, *No.* 1, 136–47 (*March*, 1955).

The variation in the composition of the penetrating component of extensive air showers at sea level has been investigated as a function of shower density. The proportion of N-particles in the penetrating component was observed to decrease as the shower density decreased. It is suggested that this behaviour is due to the filtering action of the atmosphere on the more absorbable particles in the nuclear cascade which has passed maximum development. The zenith-angle distribution of the penetrating μ-mesons in air showers has been found to be of the form $\cos^8\theta$ which is consistent with that expected for shower axes, and gives no evidence for the broader distribution reported at mountain altitudes. An anomalous deficiency of penetrating μ-mesons with zenith angles less than 5° has been found in air showers of median density $10\,m^{-2}$. A.

537.591.15

6270. The second maxima in the transition curve of cosmic ray showers. J. B. Harding. Letter in *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 352–4 (*April*, 1955).

Briefly describes some experimental measurements on the transition curve and points out that the second maximum probably arises from the decay electrons emitted by μ-mesons decaying in the ground immediately below the apparatus. H. ELLIOT

537.591.5

6271. The diurnal variation of the cosmic radiation. I. E. Remy and A. Sittkus. *Z. Naturforsch.*, **10a**, *No.* 2, 172–3 (1955) In German.

These have been continuously recorded at Freiburg with a double coincidence telescope of effective areas $3\,000\,cm^2$ separated by 10 cm. The total rate of 200 000 coinc./hr, giving an accuracy of the hourly figures of 0·23%, has been corrected for meteorological influences. Results plotted in 120 3-day intervals show that the phase of the first harmonic deviates strongly from the annual mean of 10 hr local time (l.t.); the maximum never occurs between 16 and 21 hr l.t. Phase variations show a 27-day periodicity. Comparison with the K-figures shows that there is often a correspondence between phase and geomagnetic figures in the months June to January, but that this is not always so from February to May. In the case of magnetic disturbances accompanied by a phase shift, the greatest phase advance will occur 3 to 6 days after the maximum of the K-numbers. A decreasing amplitude of the diurnal variation after magnetic disturbances is indicated in accordance with Alfvén's calculations.

E. W. KELLERMANN

537.591.5

6272. "Knee" of the cosmic-ray latitude curve. H. V. Neher and E. A. Stern. Letter in *Phys. Rev.*, **98**, *No.* 3, 845–6 (*May* 1, 1955).

Ionization has been recorded in 1954 up to an altitude of 95 000 ft and found to increase much more steeply with decreasing air mass overhead at 89° Geomagn. N. than in 1951 at 88° Geomagn. N. Ionization *v.* geomagnetic latitude curves for various atmospheric depths show that in 1954 at $20\,g\,cm^{-2}$ the change from 58 to 68° is about 6% compared with <1% found in 1951. This difference is interpreted as being due to the presence in 1954 of low-energy particles that were absent in 1951. Indications are that in 1954, when solar activity was low, no cutoff for protons existed down to 150 MeV, compared with 800 MeV in 1951. E. W. KELLERMANN

537.591.7

6273. Nuclear disintegration cascade produced by a heavy primary. A. Milone. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 353–4 (1954).

Describes four successive interactions of a heavy primary of estimated energy > 9 GeV/nuclear. Preliminary δ-ray counts give the charge of the primary before each disintegration as 13, 8, 5 and 3.

P. ROTHWELL

537.591.8

6274. On the angular distribution in jets. G. Bertolino, D. Pescetti and L. Tallone. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 338–9 (1954) In Italian.

Measurements in progress are reported, on a group of jets observed in nuclear emulsion exposed at balloon altitudes, having both charged and neutral primaries. The results are in satisfactory agreement with those of Duller and Walker [Abstr. 3640 (1954)].

P. ROTHWELL

537.591.8

6275. Remarks on the interpretation of jets. U. Haber-Schaim. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 344–6 (1954).

Examines the possibility that jets might involve the collision of an incident nucleon with several nucleons simultaneously and indicates some of the observable consequences of such a process. Considers whether it is possible to increase the statistics on jets by relaxing the criterion for acceptance and including stars having $N_h \geqslant 2$ since N_h is quite likely to be increased by the interaction of a jet particle.

P. ROTHWELL

537.591.8

6276. Nucleon–nucleus interactions at very high energy. M. Schein, D. M. Haskin and R. G. Glasser. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 355–60 (1954).

Discusses the angular distribution of the shower particles from two large stars of types $32 + 137\,n$ and $25 + 76\,p$. Neither can be interpreted as a nucleon–nucleon collision, and it is concluded that they can only be explained in terms of pluro-multiple processes. Assuming that the primary nucleon interacts with more than one target nucleon, the primary energy for both the events is estimated to be about 10^{13} eV.

P. ROTHWELL

537.591.8

6277. Generation of the π-meson of cosmic radiation by nuclear-active particles of moderate energies. G. B. Zhdanov. *Uspekhi fiz. Nauk*, **54**, *No.* 3, 435–64 (1954) In Russian.

The purpose of this survey is an analysis of sundry properties of the elementary act of π-meson generation in the energy interval for primary nuclear active particles of 10^9–10^{10} eV. This range of energies is of

interest in its bearing upon the process of nuclear interaction with the matter of the atmosphere and the creation of all components of secondary radiation. The range of energies quoted is one which the big accelerators will soon be providing. Experimental methods are discussed very briefly, also the nature and intensity of components generating π-mesons in dense media and in the atmosphere. The angular distribution of π-mesons in the elementary act of generation and the meson energy spectrum are also discussed. Ninety refs. covering work in the last five years.

C. R. S. MANDERS

537.591.8

6278. The statistics of 29 000 stars observed in nuclear emulsions in Kenya. K. R. Dixit. *Z. Naturforsch*, **10a**, *No.* 4, 339–41 (1955).

29 182 stars observed at mountain altitudes in Kenya are analysed statistically. The analysis gives: (1) an absorption thickness of 149 g/cm^2 near the geomagnetic equator; (2) the star frequency as a function of the total number of prongs in a star is the result of the composition of the emulsion; (3) the empirical formula of Teucher for the energy of the star-producing particle can be used in the experiments; (4) the variation in the number of shower particles with the complexity of the star and the altitude appears to be in agreement with the Heisenberg theory of the plural production of mesons. A.

537.591.8

6279. Example of a probable Λ_0 particle of high energy. A. De Marco, A. Milone and M. Reinharz. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 744–5 (*April*, 1955) In Italian.

Describes an event observed in nuclear emulsion exposed at balloon altitudes that is interpreted as the disintegration in flight of a Λ_0-particle of energy $\sim 5 \pm 1$ GeV. P. ROTHWELL

537.591.8

6280. On the production of secondary electrons by high energy μ-mesons. G. Caglioti, S. Sciuti and A. Gigli. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 851–62 (*May*, 1955).

With a counter hodoscope expressly designed for the study of secondary electrons, the generation of electronic secondaries in successive layers of material (Al or Pb) by μ-mesons has been studied. An examination of these results, in conjunction with hodoscope data already in part published, shows that the discrepancies between cloud chambers and hodoscope measurements can be fully explained. A.

537.591.8

6281. Results on some secondary particles of *K*-mesons from the stacks flown in Sardinia 1953. A. Bonetti, R. L. Setti, B. Locatelli and G. Tomasini. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 904–14, (*May*, 1955).

Among the 8 secondaries, one has been identified as a π-meson, one as a μ-meson. The other 6 form a group whose ionization is near the plateau and whose $p\beta$ is about 200 MeV/c. The *K*-particle with π-meson secondary can be classed as a χ-meson, that with an identified μ-secondary is probably a κ. The remaining 6 secondaries can be interpreted as the products of the K_μ decay, and the mass of the K_μ can be determined from their mean $p\beta$. The methods of measurement and some possible sources of error are discussed critically. A.

537.591.8 : 539.18

6282. Electromagnetic interactions of μ-mesons in arrangements of counters. D. Kessler and R. Maze. *Physica*, **21**, *No.* 5, 425–40 (*May*, 1955) In French.

A critical study of previous experiments on penetrating showers produced by μ-mesons showed the need for an extensive investigation of the contribution of the soft secondary component of μ-meons to the counting-rate in penetrating shower counter-arrangements. This paper describes various experiments to investigate the effect of this soft secondary radiation of μ-mesons on counters embedded in lead. At small distances from the meson trajectory counters are triggered by electron secondaries, but at distances of more than 0·8 cm Pb the contribution of photons in the 2–7 MeV range becomes dominant. The intensity of soft radiation in equilibrium with μ-mesons depends slightly on the energy of the primaries, as shown by the well-known relative increase of soft showers with depth underground compared to the flux of penetrating particles. This effect is investigated quantitatively. Conversely, any experimental requirement for soft secondaries modifies the energy spectrum of incident μ-mesons. As a consequence, two or more events of this type cannot be considered as independent. This effect is here investigated with regard to penetrating shower counter-arrangements at stations between sea level and 65 m.w.e. underground. Experimental results show fair agreement with the calculations. By way of illustration, the increase of the mean energy of the μ-meson spectrum produced by some trivial experimental requirements has been calculated, and comes out surprisingly large in some cases. A.

537.591.8

6283. On star production by μ-mesons underground. G. N. Fowler. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 6, 482–8 (*June*, 1955).

The application of Williams's method to underground star production by μ-mesons is discussed. It is shown that the virtual photon spectrum derived by Williams is not applicable to this process and the appropriate virtual photon spectrum is deduced. The results on star production are then re-examined and it is shown that photo-nuclear effects are unable to explain the observed cross-sections. The relationship of this result to the observations on the anomalous scattering of μ-mesons is also discussed. A.

MAGNETISM 538

538.082/.083

6284. The apparatus used in the original experiments on the Barkhausen effect and the question of the reproducibility of the effect. K. Wotruba. Letter in *Czech. J. Phys.*, **5**, *No.* 1, 98–100 (*Feb.*, 1955) In German.

The apparatus used by Bush and Tebble [Abstr. 1280 (1948)] was modified by increasing the number of discriminators to five and including an electrolytic potentiometer in the circuit. An alternative method

of calibration, using an artificial magnetic dipole, was also used. Measurements on an iron specimen gave practically reproducible results. E. P. WOHLFARTH

538.082

6285. New method of testing the compensation of the earth's magnetic field for investigations with vertical astatic magnetometers. A. I. DROKIN. *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 199–200 (1955) In Russian.

It is suggested that use is made of the hysteresis effect on warming and cooling a ferromagnetic through the Curie point to get a very sensitive test of the correctness of compensation. Hopkinson's effect is such that on cooling, just below the Curie point there is a very large maximum in the intensity of magnetization for very small fields. J. M. HOUGH

538.083.9 : 539.152.1

6286. Measurement of a magnetic field with the use of proton magnetic resonance. N. I. LEONT'EV. *Zh. éksper. teor. Fiz.*, **28**, *No.* 1, 77–84 (1955) In Russian.

The exact frequency of proton resonance is used to determine magnetic fields to 0·006% from 1 000 to 7 000 Oe. A feedback servo arrangement adjusts the oscillator so that resonance occurs exactly at the centre of the modulation sweep. Circuit diagrams are given. D. H. WHIFFEN

538.12

6287. Demagnetising energies of uniformly magnetised rectangular blocks. P. RHODES AND G. ROWLANDS. *Proc. Leeds Phil. Lit. Soc.*, **6**, *No.* 4, 191–210 (*Dec.*, 1954).

Results are given of calculations of the magnetostatic self-energies of the following structures: (i) a uniformly magnetized rectangular block, (ii) a rectangular block containing an infinitely thin 180° domain boundary, (iii) a rectangular block containing several equispaced 180° boundaries. The applications of the results of such calculations to specific problems are outlined. E. P. WOHLFARTH

538.12

6288. The boundary conditions for magnetic media with infinite permeability. É. DURAND. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 11, 1197–200 (*March* 14, 1955) In French.

Investigates the generality of the condition that the lines of induction are normal or tangential to the surface bounding a medium $\mu = \infty$. E. P. WOHLFARTH

538.214

6289. Correction for ferromagnetic susceptibility [due to ferromagnetic impurities] in magnetochemical investigations using the cylinder method. A. KNAPPWOST. Note in *Naturwissenschaften*, **42**, *No.* 7, 175 (1955) In German.

The Honda formula is generalized to apply to field strengths below that giving ferromagnetic saturation, and the applicability of the new formula is outlined. E. P. WOHLFARTH

538.22

6290. Magnetic susceptibility of hafnium and manganese. C. J. KRIESSMAN AND T. R. MCGUIRE. *Phys. Rev.*, **98**, *No.* 4, 936–7 (*May* 15, 1955).

The magnetic susceptibility of hafnium, which has been measured from 4·2 to 1 670°K, increases with increasing temperature above 77°K. At room temperature, the susceptibility is $(0{\cdot}42 \pm 0{\cdot}01) \times 10^{-6}$ e.m.u./g. The susceptibility of manganese between 77°K and room temperature shows a maximum at 125°K. This can be identified with antiferromagnetism by a correlation with neutron diffraction data. In the temperature region below 77°K the susceptibility increases again quite rapidly. A.

538.22 : 535.371

6291. Magnetic properties of zinc sulfide and cadmium sulfide phosphors. S. LARACH AND J. TURKEVICH. *Phys. Rev.*, **98**, *No.* 4, 1015–19 (*May* 15, 1955).

Measurements of magnetic susceptibility were made of various preparations of zinc sulphide and cadmium sulphide by the Gouy method, from 77 to 300°K. The materials differed in crystalline state and modification, type and content of impurities, methods of preparation and neutron radiation treatment. No temperature-dependent paramagnetism was found for either the zinc sulphides or the cadmium sulphides. The diamagnetism was dependent on the variables cited above. Uncrystallized zinc sulphide obtained by precipitation had a specific diamagnetic susceptibility of $-0{\cdot}36 \times 10^{-6}$, while that of cadmium sulphide was $-0{\cdot}268 \times 10^{-6}$. On crystallization, the susceptibility values obtained depended on whether air, nitrogen or hydrogen-sulphide atmospheres were used during the crystallization, and whether chloride or aluminium ion "flux" was used. Only small differences were found in the susceptibilities of the cubic and of the hexagonal forms of zinc sulphide. It has been postulated that Cl^{-1} or Al^{+3} aided in the luminescence of zinc sulphide phosphors by allowing the formation of monovalent zinc, through charge compensation. It would be expected that this monovalent zinc would give rise to a temperature-dependent paramagnetic species. No such paramagnetism was found. Instead, the diamagnetism increases, suggesting that the rôle of the Cl^{-1} and Al^{+3} ions is to perturb the lattice. The radial extent of such a perturbed volume in a zinc sulphide phosphor, optimally activated with Ag or Cu, is calculated as approximately 50 Å. The luminescence centre in such phosphors is identified with the metallic activator surrounded by the perturbed volume. High-intensity neutron bombardment of a zinc sulphide: Cu phosphor causes a marked increase in the value of the diamagnetic susceptibility. A.

538.221

6292. Experimental investigation of the topography of the magnetic field of natural surface defects in ferromagnetic solids. N. N. ZATSEPIN. *Zh. tekh. Fiz.*, **24**, *No.* 7, 1224–8 (1954) In Russian.

By contradistinction to the case of artificial defects, the magnetic fields of natural surface defects of ferromagnetic solids, viz. hair cracks, are never measured. The author shows that despite experimental difficulties such measurements can be carried out with a modest accuracy. The sensitivity of the bismuth wire as indicator of the magnetic field was increased by carrying through the measurements in a Dewar vessel at liquid nitrogen temperature. The results obtained could be confirmed by metallographic microsections which are reproduced in the paper in magnifications of × 90 and ×210, respectively.

B. F. KRAUS

538.221

6293. The origin of the permeability change of iron–silicon single crystals by means of magnetic annealing. H. FAHLENBRACH. Note in *Naturwissenschaften*, **42**, *No.* 7, 174–5 (1955) In German.

Reports powder pattern and initial magnetization measurements on picture frame specimens of 3·5% Si–Fe. The movement of 180° domain boundaries parallel to the [100] direction was found to take place in much lower fields after magnetic cooling than without. It is suggested that rotational processes in the [110] limbs of the frame take place more easily after magnetic cooling. E. P. WOHLFARTH

538.221

6294. Characteristic Bitter figures on silicon–iron crystals with internal strains. W. STEPHAN. *Ann. Phys.* [*Leipzig*] **15**, *No.* 5–6, 337–44 (1955) In German.

Powder patterns on internally strained 4% Si–Fe crystals which have been electrolytically polished reveal the presence of zigzag boundaries. The patterns on quenched specimens have a maze-like character. The effects of field reversals normal to the specimen surface were also investigated.

E. P. WOHLFARTH

538.221

6295. Magnetic properties of FeTe. E. UCHIDA AND H. KONDOH. *J. Phys. Soc. Japan*, **16**, *No.* 5, 357–62 (*May*, 1955).

The susceptibility-temperature relation for the compound FeTe was measured over a range of temperatures between liquid air and 1150°C. Evidence was found of an antiferromagnetic character in the region of temperatures below 500°C, the molal magnetic susceptibility having been expressed by $\chi = 0{\cdot}92/(T + 220)$. The effective number of Bohr magnetons was estimated to be 2·72. The susceptibility dependence on temperature in the region beyond 600°C showed evidences of the feeble constant paramagnetism and an anomaly at 815°C, which is the melting point of this compound. A tentative interpretation of these magnetic properties is given in terms of an electronic configuration of Fe. A.

538.221

6296. Ferromagnetic resonance in Ferroxdure. M. T. WEISS AND P. W. ANDERSON. *Phys. Rev.*, **98**, *No.* 4, 925–6 (*May* 15, 1955).

Ferromagnetic resonance experiments have been performed on Ferroxdure at various microwave frequencies from 9000 Mc/s to 50000 Mc/s. With no externally applied field a natural resonance occurs near 50000 Mc/s. With magnetic field applied perpendicular to the hexagonal axis, a double resonance occurs for frequencies below 50000 Mc/s, while with a field applied along the hexagonal axis a single resonance occurs above 50000 Mc/s. A theory is developed to explain the above results. A.

538.221

6297. Some magnetic properties of dilute ferromagnetic alloys. I. G. BATE, D. SCHOFIELD AND W. SUCKSMITH. *Phil. Mag.*, **46**, 621–31 (*June*, 1955).

The theory of the coercivity of non-spherical, single domain particles of ferromagnetic material in a non-magnetic matrix has been developed independently by Néel (1947) and Stoner and Wohlfarth (1948). Appropriate conditions for the study of the growth of these domains are to be found in suitable dilute ferromagnetic alloys where there is an increase of solubility of the ferromagnetic constituent with temperature. Such characteristics are found in the copper-rich alloys of copper–cobalt and copper–iron. The magnetic properties of appropriate alloys with increase of heat treatment are followed from the normal paramagnetism of the solid solution to the ordinary magnetization curve of the precipitated ferromagnetic. At a suitable stage a maximum in the coercivity is found which the writers believe to be associated with single domain precipitates. The characteristics of the hysteresis loops at this stage indicate the presence of high coercivities of more than 1000 Oe. A.

538.221 : 537.32 : 538.63

6298. Preliminary report on the magneto-thermoelectric power of nickel. N. MIYATA AND Z. FUNATOGAWA. *Sci. Rep. Yokohama Nat. Univ. I*, *No.* 3, 13–18 (*March*, 1954).

This was measured by the same method as that used for iron. The results show positive signs and that (1) the magneto-thermoelectric power has a maximum at about −90°C and then decreases with decreasing temperatures and may tend to zero at 0°K, and (2) the magneto-thermoelectric powers between −90 and about 300°C decrease with increasing temperatures but (3) in the neighbourhood of the Curie point they are negative signs and are produced by additive magnetizations, which are proportional to the external magnetic fields, expected from the Weiss theory. A.

538.222

6299. Paramagnetic resonance in carbonaceous solids. D. J. E. INGRAM, J. G. TAPLEY, R. JACKSON, R. L. BOND AND A. R. MURNAGHAN. Letter in *Nature* [*London*] **174**, 797–8 (*Oct.* 23, 1954).

Coal shows electron resonance signals, $g = 2{\cdot}0030$, line width 8 ± 2 gauss independent of frequency. The intensity rises rapidly with carbon content (rank) reaching that for 3×10^{19} free radicals/g at 94% C. The signal increases after carbonization at temperatures up to 550°C, but disappears with carbonization above 650°C. D. H. WHIFFEN

538.222

6300. Theory of *g*-values and spin-lattice relaxation for paramagnetic resonance in conduction electrons. R. J. ELLIOTT. *Defects in crystalline solids* [*Bristol*] 121–3. See Abstr. 5707 (1955).

538.222

6301. The magnetic properties of ions of the first transition group, from $3d^5$ to $3d^{10}$, in amidosulphonate compounds. N. PERAKIS AND T. KARANTASSIS. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 13, 1407–9 (*March* 28, 1955) In French.

An extension of previous susceptibility measurements [Abstr. 5196 (1952)] on the substances $(NH_2SO_3)_2M$ to include M = Mn, Fe, Co, Ni, Cu, Zn. The p_B values calculated from the measurements permit the orbital contribution to the total moment to be estimated. E. P. WOHLFARTH

538.222

6302. The magnetic ground state of UF_3. M. C. M. O'Brien. Letter in *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 351–2 (*April*, 1955).

Makes deductions as to the configurations and types of coupling in the U^{3+} ion from the measured *g*-values of UF_3 [Abstr. 11207 (1954)]. The ground state is shown to have the configuration $5f^3$.

E. P. WOHLFARTH

538.222

6303. Spin-lattice relaxation time of the Si^{29} nucleus in pure fused silica. G. R. Holzman, J. H. Anderson and W. Koth. Letter in *Phys. Rev.*, **98**, *No.* 2, 542–3 (*April* 15, 1955).

The Si^{29} nuclei were observed to approach equilibrium magnetization exponentially in a field $9{\cdot}2\times10^3$ oersted with a relaxation time 10 hr at room temperature. E. P. WOHLFARTH

538.222

6304. Measurement of the magnetic susceptibility of manganese nitride Mn_5N_2 by a microvibration method. Y. L. Yousef, R. K. Girgis and H. Mikhail. *J. chem. Phys.*, **23**, *No.* 5, 959–63 (*May*, 1955).

The susceptibility-temperature relationship of carefully prepared manganese nitride Mn_5N_2 was measured over the temperature range -180 to 530°C. The Curie–Weiss law $\chi = C/(T-\theta)$ was found to hold, with $\theta = -1070$ and $C = 0{\cdot}0316$ e.m.u. deg/g. The effective Bohr magneton number is 3·94 per Mn, and is in reasonable agreement with the theoretical value 3·87 for 3 unpaired electrons. This suggests that Mn_5N_2 behaves as a co-ordination compound with 4 electron-pair bonds. A new microvibration technique, particularly suitable for susceptibility investigations of materials available in small amounts, has been developed for the present work. The underlying principle is to modulate the magnetic field and to translate the periodic force on the material into a periodic displacement of an elastic strip. The force is measured dynamically in terms of a compensating electrostatic force, an electronic circuit being used as a null detector. Accuracy to 10^{-4} dyne is claimed. A.

538.222

6305. On the hyperfine structure of paramagnetic resonance: the *s*-electron effect. A. Abragam, J. Horowitz and M. H. L. Pryce. **Appendix.** K. W. Morton. *Proc. Roy. Soc. A*, **230**, *No.* 1181, 169–87 (*June* 21, 1955).

Unpaired *s*-electrons play an important part in hyperfine spectra, even when the nominal spectroscopic configuration contains no unpaired *s*-electrons. This situation occurs in paramagnetic resonance and optical spectra. A survey of the experimental evidence for the effect is given in relation to the paramagnetic ions and the neutral atoms of the 3*d* transition elements. It appears that the central density of unpaired spin is nearly the same in all the ions of the group for which experimental data are available, while for the neutral atoms it is more variable, but of the same general magnitude. A calculation of the magnitude of the effect is attempted from first principles, starting from the Hartree–Fock self-consistent wave-functions as a first approximation, and adding configurations in which 3*s*-, 2*s*- and 1*s*-electrons are promoted. The promotion of a 3*s*-electron is described by an integrodifferential equation, which has been solved numerically in one particular case. The contribution turns out of the right sign but ten times smaller than the observed value. Promotion of 2*s*- and 1*s*-electrons yield similar equations, which, however, have not been solved, owing to the excessive labour involved. There is no reason to believe that they would not give smaller contributions still. The full explanation of the *s*-electron effect is thus still an open question. A.

538.222 : 534.321.9 : 539.132

6306. Resonance absorption of ultrasound in paramagnetic salts. S. A. Al'tshuler. *Zh. éksper. teor. Fiz.*, **28**, *No.* 1, 38–48 (1955) In Russian.

Ultrasonic radiation of the resonance frequency for a paramagnetic salt in a magnetic field may be absorbed. The sound absorption coefficient, σ, depends on the spin-lattice interactions. It is especially small if the lowest energy level at zero field is a Kramers doublet which is not affected by oscillating electric fields to first order. Full theoretical details are given for the general cases. Approximate values for σ in cm^{-1} are $2{\cdot}4\times10^{-38}\nu^4$ for CsTi alum at 20°K; $\sigma_\perp = 0{\cdot}80\times10^{-21}\nu^2$, $\sigma_\parallel = 0{\cdot}56\times10^{-23}\nu^2$ for K, Cr alum at 300°K; $4\sigma_\perp = \sigma_\parallel = 3\times10^{-44}\nu^4$ for Ce nitrate at 20°K; $\sigma = 10^{-3}\nu^2$ for Pr ethyl sulphate at 20°K; $\sigma = 10^{-24}\nu^2$ for RbFe alum. With $\nu = 10^9$ c/s some of these absorptions should be just detectable. See also abstract following. D. H. WHIFFEN

538.222 : 534.321.9 : 539.132

6307. On the theory of electron and nuclear paramagnetic resonance under the influence of ultrasound. S. A. Al'tshuler. *Zh. éksper. teor. Fiz.*, **28**, *No.* 1, 49–60 (1955) In Russian.

See also preceding abstract. Similar full theoretical calculations of σ are given for electron and nuclear resonance. $\sigma = 0{\cdot}7\times10^{-19}\nu^2\,cm^{-1}$ for MnF_2 at 300°K, $\sigma \sim 10^{-16}\nu^2\,cm^{-1}$ for β-Ce at 300°K, $\sigma \sim 10^{-25}\nu^2\,cm^{-1}$ for NaBr and $\sigma = 10^{-28}\nu^2\,cm^{-1}$ for a hypothetical case with quadrupole interaction assuming $Q = 10^{-25}\,cm^2$. For liquids the nuclear effect is larger, and for water whose proton relaxation time is reduced to 10^{-4} sec by paramagnetic impurities $\sigma = 10^{-2}$ at $\nu = 10^7$ c/s. In some cases absorption occurs at $h\nu = 2g\beta H$ as well as $h\nu = g\beta H$.

D. H. WHIFFEN

538.222 : 537.311.33

6308. Cyclotron and spin resonance in indium antimonide. G. Dresselhaus, A. F. Kip, C. Kittel and G. Wagoner. Letter in *Phys. Rev.*, **98**, *No.* 2, 556–7 (*April* 15, 1955).

Cyclotron resonance at 24000 Mc/s in *n*- and *p*-type InSb has been observed at 2·2°K giving peaks corresponding to effective masses $0{\cdot}013 \pm 0{\cdot}001$ m, 0·18 m and >1·2 m, as indicated by plotting power absorbed against magnetic field. The low field peak is isotropic to rotation in the (100) plane and the relaxation time is 10^{-11} sec. Electron spin resonance with $g = 2{\cdot}11 \pm 0{\cdot}03$ is also observed.

D. H. WHIFFEN

538.222 : 537.312.62

Paramagnetism observed at the superconducting transition. *See Abstr.* 6157

538.222 : 545.82

Nuclear magnetic resonance spectroscopy. *See Abstr.* 6592

538.224

6309. Diamagnetic susceptibility of the tungstate ion. K. VENKATESWARLU AND K. RAMANATHAN. Letter in *Curr. Sci.*, **24**, *No.* 3, 83–4 (*March*, 1955).

From diamagnetic susceptibility determinations on five tungstates, values ranging from $-27{\cdot}2$ to $-30{\cdot}5\times10^{-6}$ c.g.s. units have been deduced for the ionic susceptibility of the WO_4^{--} group.

G. I. W. LLEWELYN

538.245

6310. On the change of magnetization due to a small stress. Y. GONDO. *Sci. Rep. Yokohama Nat. Univ. I*, *No.* 1, 39–45 (*March*, 1952).

In these measurements the (H, σ) method was used. In iron the change of magnetization is divided into a reversible decrease, which occurs at $\sigma > 800\,g/mm^2$, and an irreversible increase, which is saturated at $\sigma = 2\,kg/mm^2$. Then from the reversible and irreversible strain sensitivities obtained here and a simple distribution of the internal stress assumed, the internal stress of annealed pure iron is estimated to be $660\,g/mm^2$. The results for iron–nickel alloys are also outlined briefly. A.

538.245 : 621.317.431 : 621.318.134

6311. A note on the rectangular magnetization loop of ferrite cores. H. KORNETZKI. *Frequenz*, **9**, *No.* 3, 81–3 (*March*, 1955) In German.

It is shown that the rectangular *B–H* loops exhibited by Mg–Mn ferrite cores are not due to any anisotropic physical property of the material but are a consequence of the low excitation normally used for switching service. A curve is taken for a large rectangular-section toroid and then two small toroids are cut from it: one normal to a radius, one normal to a tangent. The curves from these samples are, within experimental error, the same as for the original ring. A similar phenomenon has been noted in electrolytic iron cores. S. C. DUNN (R)

ELECTROMAGNETISM . ELECTRODYNAMICS 538.3/.5

538.3

6312. Velocity of light in moving isotropic bodies. E. CLAUSER. *R.C. Accad. Naz. Lincei*, **17**, *No.* 6, 362–5 (*Dec.*, 1954) In Italian.

538.3

6313. Concerning the electric and magnetic homology associated with plane waves in moving bodies. G. CARINI. *R.C. Accad. Naz. Lincei*, **17**, *No.* 6, 358–61 (*Dec.*, 1954) In Italian.

The results obtained for a homogeneous isotropic body moving with uniform velocity $\mathbf{v}$ are $n^2(c^2 - v^2)\mathbf{B} = \xi\mu\mathbf{H} + \mu(\mathbf{v}\,.\,\mathbf{H})\mathbf{a}$, and $n^2(c^2 - v^2)\mathbf{D} = \xi\varepsilon\mathbf{E} + \varepsilon(\mathbf{v}\,.\,\mathbf{E})\mathbf{a}$, where ξ and $\mathbf{a}$ depend on $\mathbf{v}$ and on the direction of propagation of the wave, and $n^2 = \varepsilon\mu$.

R. A. NEWING

538.3

6314. An integral equation governing electromagnetic waves. P. R. GARABEDIAN. *Quart. appl. Math.*, **12**, *No.* 4, 428–33 (*Jan.*, 1955).

A certain boundary-value problem for the Helmholtz equation $\Delta u + k^2u = 0$ is reduced to a Fredholm integral equation, by introducing a suitable parametrix constructed by means of a conformal mapping. The integral equation is developed and a variational formula is derived for estimation of the scattering cross-section. L. S. GODDARD

538.55

6315. Nets composed of parts of circles for the approximate solution of field problems. L. TASNY-TSCHIASSNY. *Austral. J. Phys.*, **8**, *No.* 1, 8–29 (*March*, 1955).

The two-dimensional differential equation $\partial/\partial x[\sigma(\partial\phi/\partial x)] + \partial/\partial y[\sigma(\partial\phi/\partial y)] + \tau = 0$ describes the current flow in a sheet of conductivity σ loaded by a transverse current density $(-\tau)$, ϕ being the electrical potential. It is known that this equation can be solved approximately by a procedure in which the two-dimensional continuum is replaced by a net of straight-line bounded meshes, leading to an electrical network of conductances. The author shows that meshes bounded by "curvilinear rectangles" can be equally well dealt with and, on the basis of different conformal transformation functions for the individual meshes, derives the formulae required for a solution, if the mesh boundaries are circle arcs or circle arcs and straight lines. A good fit of the contours of the boundaries and equipotentials and their orthogonal trajectories can be obtained. This reduces the number of meshes without impairing the accuracy. Sharp corners at boundaries can be dealt with in a similar way. Formulae for a good accuracy computation of potential gradients and a method for changing the mesh size abruptly are given. Two examples using nets of only four meshes demonstrate the power of the method, the maximum errors being of the order of a few per cent. A.

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.56 : 532.51

6316. On the reflection and refraction of hydromagnetic waves. P. H. ROBERTS. *Astrophys. J.*, **121**, *No.* 3, 720–30 (*May*, 1955).

It is supposed that a plane harmonic hydromagnetic wave encounters the plane surface separating two fluids of infinite conductivity. The general laws of reflection and refraction are derived and are shown to depend on the orientation of the permanent uniform magnetic field which provides the exciting agency of the waves. In contrast to a similar problem solved by Ferraro (1954), the incident wave is supposed to have an arbitrary polarization. It is found that if this polarization has a component perpendicular to the interface, a disturbance is generated whose effect decays exponentially with distance from the interface. The skin depth of this disturbance is the same in both fluids and is infinite if the angle of incidence is zero.

It is also found that, whatever the direction of incident polarization, the interface is undisturbed by the incoming wave. The reflection of a hydromagnetic wave from a free surface is also discussed. A.

538.561 : 537.525.8

Microwave and metre wave radiation from the positive column of a gas discharge. *See Abstr.* 6184

538.561 : 621.385.833

6317. Plasma ion oscillations in electron beams. K. G. HERNQVIST. *J. appl. Phys.*, **26**, *No.* 5, 544–8 (*May*, 1955).

The frequency of the oscillations observed in ion-neutralized electron streams such as that of an ion trapping gun or of a tetrode has been shown to agree well with the Langmuir–Tonks theory for plasma-ion oscillations. The existence of a dipole mode of oscillation in addition to the longitudinal mode has been observed for a plasma column. A mechanism is proposed for the excitation of these self-sustained oscillations by which the secondary electron current from electrodes bounding the plasma is modulated by the vibration of the ions in such a way as to deliver energy to the a.c. field associated with the ion oscillations. Experimental observations verify this picture as far as the source of energy is concerned. A.

538.565 : 621.372.413

6318. The effect of surface scratches on the losses in resonant cavities for microwaves. U. PELLEGRINI. *Alta Frequenza*, **24**, *No.* 1, 12–21 (*Feb.*, 1955) In Italian.

A demountable X-band cavity working in TE_{011} mode in the form of a right circular cylinder could have its internal surface finished in 3 ways with 3 different metals. The ways were: as turned on a lathe, electrolytically plated, polished with abrasive paste. The metals were: brass, copper and silver. The Q-factor of the cavity was measured at 9 635 Mc/s using a spectrum analyser connected to the probe of a standing-wave indicator. The relation given by Brown and Rose is used [Abstr. 8340 (1952)]. Values up to about 10 000 were recorded. For a given material, polishing gives better results than plating. Independent of the material, but according to its roughness the turned surface is worse than the plated surface. The measured values of Q tend to agree with theory only when the size of the scratches is small compared with the calculated skin depth.

S. C. DUNN (R)

538.566 : 621.372.8 : 621.396.11

6319. Study of the diffraction of electromagnetic waves by a network of perforated plates. G. BROUSSAUD. *Ann. Radioélect.*, **10**, 42–63 (*Jan.*, 1955) In French.

An examination of an artificial dielectric formed by a stack of metal plates perforated by a matrix of circular holes, with a view to its application to microwave lenses. Consideration of the symmetry of the field in the apertures leads to a representation by means of a system of guided propagations. At oblique incidence these propagations become coupled giving rise to refraction. For a wave polarized parallel to the plane of incidence, a critical angle of incidence exists (determined by the hole spacing), at which all the energy is absorbed by modes propagating between the plates. For angles of incidence $>30°$ a simple calculation provides a precise analysis of the behaviour of the lens in terms of easily measurable parameters. G. D. SIMS (R)

538.566

6320. On thermal radiation in waveguides. S. M. RYTOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11) 571–8 (1954) In Russian.

The equations of thermal equilibrium are extended to cover the effect of attenuation of waves below cutoff and the skin effect. J. M. HOUGH

538.566.3

6321. On the calculation of the collision frequency in the ionosphere. L. CAPRIOLI. *R.C. Accad. Naz. Lincei*, **17**, *No.* 6, 365–70 (*Dec.*, 1954) In Italian.

It is shown that, if the apparent height of reflection and the absorption are known for all waves whose real heights of reflection exceed a value z_0, and if the ionic density $N(z)$ and the collision frequency $\nu(z)$ are known for $z < z_0$, then N and ν can be determined, by solving an Abel integral equation, also in the interval $z_0 < z \leqslant z_E$, where z_E is the height at which $N(z)$ reaches its first maximum. L. PINCHERLE

538.566.3

6322. Graphical constructions for ray-tracing in the ionosphere. R. F. MULLALY. *Physics of the ionosphere* [*Cambridge*] 384–93. See Abstr. 5763 (1955).

A method of Poeverlein's [Abstr. 7393 (1950)] for plotting the paths of rays through the ionosphere in the presence of the earth's magnetic field is extended to deal with rays not lying in the magnetic meridian. The paths of these rays are in general tortuous curves. The method employs the curves showing the refractive index μ as a polar function of the direction of phase propagation. By a further construction it is shown that ray-paths may be plotted without the necessity of constructing the μ-curves. It is also shown that the present procedure is equivalent to the methods employed by Booker and Millington, and that it provides a graphical solution of the fundamental quartic equation of ionospheric ray-propagation. Methods for the determination of the state of polarization along the ray, and of the level of reflection, are also given. Throughout, the effect of absorption on the ray-paths is treated as negligible. A.

538.566.3 : 551.510.535

6323. Ionospheric self-interaction of radio waves. F. H. HIBBERD. *J. atmos. terrest. Phys.*, **6**, *No.* 5, 268–79 (*May*, 1955).

A theory is developed for the self-interaction of a modulated continuous wave in the ionosphere. In general, self-interaction will result in a reduction of modulation of a modulated wave and in the generation of harmonics of the original modulation frequency in its passage through the ionosphere. The effects should be greatest for a high-power, medium- to low-frequency wave with low modulation frequency. The magnitude of the demodulation appears to be sufficiently large to measure. It is possible to determine from it the electron collision frequency in the lower E-layer. Effects near the gyro-frequency have not been considered. A.

538.566.3 : 621.396.11

6324. Ionospheric absorption at low and medium frequencies. G. McK. Allcock. *Physics of the ionosphere* [*Cambridge*] 14–19. See Abstr. 5763 (1955).

A preliminary analysis of the combined results of measurements by many workers of ionospheric absorption of radio waves of frequencies from 16 kc/s to a few Mc/s. It is shown that oblique-incidence results at a frequency f can be simply related to vertical-incidence results in terms of an equivalent vertical frequency $f \cos i$, where i is the angle of incidence of the oblique-incidence waves on the ionosphere. In this way a first-order approximation to the variation of absorption with frequency and distance has been obtained. A.

538.566.3 : 621.396.11

6325. A study of vertical incidence ionospheric absorption at 2 Mc/s. W. J. G. Beynon and K. Davies. *Physics of the ionosphere* [*Cambridge*] 40–52. See Abstr. 5763 (1955).

The results of a study of the seasonal and diurnal variations of the ionospheric absorption of 2 Mc/s radio waves measured at vertical incidence at Swansea are presented. The measurements consisted of visual amplitude observations using conventional pulse equipment, care being taken to minimize sampling errors. The principal conclusions are: (1) For March to October the seasonal and diurnal variations in absorption ($-\log \rho$) can be represented by an expression of the form $-\log \rho = A + BF(f/fE) \cos \chi$; f is the signal frequency, fE the E-layer critical frequency, χ the solar zenith angle. The function F is that given by Jaeger in his analysis of absorption by a Chapman-type layer; (2) the term A shows a variation with sunspot number which is in good agreement with the long-period solar cycle changes in absorption; (3) November to February are characterized by exceptionally high absorption. An expression of the above type still applies to the diurnal variation in these months, but the general level of absorption is abnormally higher. Results from other observations on this winter anomaly are considered. A.

538.566.3 : 621.396.11

6326. Short-wave echoes from the lower ionosphere. W. Dieminger. *Physics of the ionosphere* [*Cambridge*] 53–7. See Abstr. 5763 (1955).

The characteristics of echoes on short waves from heights between 75 and 95 km as observed at Lindau/Harz are described. Preliminary results of a comparison with ionospheric absorption on short and long waves are reported. A.

538.566.3 : 621.396.11

6327. *D*-Region echoes observed with a radio wave of frequency 1·4 Mc/s. S. Gnanalingam and K. Weekes. *Physics of the ionosphere* [*Cambridge*] 63–70. See Abstr. 5763 (1955).

By means of an experimental method of unusual sensitivity [Gnanalingam, Abstr. 10685 (1954)] a search has been made for weak echoes from the ionosphere using radio frequencies near 1·4 Mc/s. Echoes could be observed if the reflection coefficient was $>3\times10^{-5}$ (attenuation 10 nepers). On several occasions during the winter months echoes could be detected during the daytime from heights in the D-region of 75–90 km. Sometimes these echoes were detectable at the same time as echoes from the E-region (from heights of ~110 km), but at other times the E-region echoes were absent. On the occasions when D-region echoes were observed, the absorption of waves of 2 Mc/s reflected from the E-region was abnormally high and this abnormal absorption was greater when the D-region echoes were observed alone. The significance of these observations is discussed. A.

538.566.3 : 621.396.11

6328. Self-gyrointeraction. S. N. Mitra. *Physics of the ionosphere* [*Cambridge*] 71–3. See Abstr. 5763 (1955).

The phenomenon of self-gyrointeraction implies that when a sender is working near gyrofrequency, the received percentage modulation at a distant point on this transmission is markedly less than the percentage modulation impressed on the carrier at the sending end. An experiment was made by All India Radio in February, 1954, utilizing its network of m.w. broadcast transmitters to find out the effect of self-gyrointeraction. 15 senders covering the frequency range of 590–1 490 kc/s were made to radiate 1 000 c/s tone, the percentage modulation being kept fixed at 80. The percentage modulation of the received signal of all the senders was measured at Delhi. The curve of received percentage modulation against wave frequency shows a significant dip at 1 020 kc/s where the modulation was as low as 48%. The gyrofrequency at the E-layer is, therefore, 1·02 Mc/s which yields the value of H at the E-layer as 0·36 gauss, the value of the magnetic field at the ground level being 0·474 gauss. A.

538.566.3 : 621.396.11

6329. *M*-type ionospheric reflections at 150 kc/s. R. L. Schrag. *Physics of the ionosphere* [*Cambridge*] 78–87. See Abstr. 5763 (1955).

A description and interpretation of occasional observations of extraordinarily polarized echo "trains" during vertically incident radio sounding experiments, using 150 kc/s pulsed signals. These echo "trains," in addition to their unique polarizations, had low amplitudes, compared with the normal E-region echoes observed simultaneously, and exhibited unusually low successive-hop absorption. The phenomenon was detected in the course of night-time ionospheric recording employing extended-range receiving instrumentation. The experimental observations were consistent with a highly efficient M-type reflection mechanism, utilizing X-mode reflectors at approximately 120 and 230 km. According to this interpretation, a rather deep ionization "well" must have existed between regions E and F of the ionosphere. Information is also obtained concerning certain l.f. properties of sporadic E and the state of polarization of received 150 kc/s signals which had pure X-mode polarizations above 100 km. A.

538.566.3 : 621.396.11

6330. Diffuse ionospheric reflection of medium waves at night. G. J. Phillips. *Physics of the ionosphere* [*Cambridge*] 174–80. See Abstr. 5763 (1955).

Observations are described of the range of angle about the mean angle of arrival over which the main energy of a downcoming ionospheric wave is spread. A m.w. broadcasting station was received on two loop

aerials spaced about one $\lambda/4$ in the direction of the transmitter, each loop being oriented to reject the ground wave. The reflection was from the *E*-layer at moderately oblique incidence. Since the base line was too short to obtain results from amplitude difference for the two aerials, continuous records were made of (1) the phase difference, (2) the magnitude of the vector difference in radio-frequency amplitude, and (3) the amplitude at one aerial. The downcoming radiation was treated as if confined to a vertical plane containing the transmitting and receiving aerials, and the power per unit range of angle at a given angle θ to the vertical was assumed to be maximum at the mean angle of arrival θ_m and to fall off on either side according to a Gaussian distribution $\exp[-(\theta-\theta_m)^2/2\theta_0^2]$, θ_0 being a parameter determining the amount of diffusion. Values of θ_0 for Paris I (863 kc/s) received in April, 1953, at Kingswood, Surrey, averaged about 8° in the early evening, increasing to somewhat higher values towards midnight. This increase may have been due to multiple reflection. The mean angle of arrival over hourly periods remained fairly close to the value expected for a simple *E*-reflection (about 58°). A.

538.566.3 : 621.396.11

6331. The transient response of the ionosphere at low frequencies. S. A. Bowhill. *Physics of the ionosphere* [*Cambridge*] 308–19. See Abstr. 5763 (1955).

A new approach to the calculation of the properties of a radio wave reflected from a horizontally stratified ionospheric region at low frequencies. Usually, the wave equation is set up for a particular frequency; the solutions give the upward- and downward-going waves below the region. Here an infinite plane impulsive wave is imagined to enter the region from free space below it. The resulting variation of electric field with time at any point is defined to be the transient response of the region at that point. The field for a single frequency can be found by taking the appropriate Fourier component of this response. The transient response is regarded as consisting of a number of scalar functions: the first scatter due solely to the interaction of the incident impulsive field with the ionization, the second scatter due to the interaction of the first scatter with the ionization, and so on. Each scattered field is propagated with the free-space velocity. The application of this method is often prohibitively complex, but the explicit solution is given for the case of an exponential variation of electron density with height, with collisional friction and a vertical magnetic field. A.

MOLECULAR AND ATOMIC STRUCTURE
539.1

THEORY OF SOLID STATE 539.11

539.11

6332. On the limiting vibrational frequencies of a cubic ionic lattice. S. O. Lundqvist. *Ark. Fys.*, **9**, *Paper* 29, 435–56 (1955).

The vibrations of a cubic ionic lattice are investigated on the basis of a potential energy, which is a first approximation of the expression for the cohesive energy in the Heitler–London treatment of ionic crystals. Besides ordinary two-particle interactions this potential contains a term which represents a three-body interaction. This term accounts (to a first approximation) for the deviations from the Cauchy relations. The main effect of this term is the introduction of an effective ionic charge. Formulae are derived for the transverse and longitudinal frequencies of long polar vibrations under the assumption that the optical polarization can be neglected. By expressing the total polarization in terms of the dielectric constants for static and high-frequency fields more accurate formulae for the frequencies are derived, which are generalizations of those given by Szigeti for the case of central forces. Numerical applications are given for NaCl and KCl. A.

539.11

6333. Electron spin resonance experiments on metals and semiconductors. A. F. Kip. *Defects in crystalline solids* [*Bristol*] 38–43. See Abstr. 5707 (1955).

Spin resonance absorption by conduction electrons in some alkali metals has been investigated. Most of the work has been done at 300 Mc/s. Resonance in bulk samples is interpreted on the basis of theory developed by F. Dyson which takes account of the motion of the charge carriers in and out of the skin depth of the metal. Line shapes give definite proof that the spin carriers are in motion. Spin resonance at 9 000 Mc/s has been observed in *n*- and *p*-type silicon semiconductors under temperature conditions such that the charge carriers are not bound. At low temperatures the carriers are trapped at the impurity atoms and no longer give observable spin resonance absorption. In addition, unexplained *p*-type resonances with line intensities not proportional to impurity concentration are observed in both *n*- and *p*-type silicon. A.

539.11

6334. Electron spin resonance absorption in metals. I. Experimental. G. Feher and A. F. Kip. *Phys. Rev.*, **98**, *No.* 2, 337–48 (*April* 15, 1955).

This was investigated at 300 and 9 000 Mc/s, in the temperature range from 4 to 296°K. The metals investigated were: Li, Na, K, Be, Mg, Al, Pd, W. Resonances were observed in Li, Na, Be, for which accurate g values and relaxation times were obtained and compared with existing theories. K gave a signal only at 4°K and 300 Mc/s, with too poor a signal-to-noise ratio to make accurate measurements. No resonances were observed in Mg, Al, Pd, W. The shapes predicted by Dyson's theory for the resonance absorption in metals were checked experimentally for different diffusion times and relaxation times. A satisfactory agreement between the theory and experiment is obtained for both the normal and the anomalous skin effect region. A.

539.11

6335. Electron spin resonance absorption in metals. II. Theory of electron diffusion and the skin effect. F. J. Dyson. *Phys. Rev.*, **98**, *No.* 2, 349–59 (*April* 15, 1955).

The theory of paramagnetic resonance absorption

by the conduction electrons in a metal is worked out, taking into account the diffusion of the electrons in and out of the thin skin into which the radiofrequency field penetrates. Calculations are carried through in detail for the case of a flat metal plate. It is found that the diffusion has no marked effect on the width of the resonance absorption line, but has a radical effect on the shape of the line. In particular, for a piece of metal thick compared to the skin depth and with a relaxation time long compared to the diffusion time, the line is antisymmetrical about its centre and has an unusual characteristic shape. A.

539.11

6336. Diffusion effects in magnetic resonance of the alkali metals. C. P. SLICHTER. *Defects in crystalline solids* [*Bristol*] 52–9. See Abstr. 5707 (1955).

Nuclear magnetic resonance studies of line widths and spin-lattice relaxation times T_1 have been made in Li, Na and Rb at various temperatures and with different static magnetic fields for each substance. Original work of this type was done by Gutowsky and by Norberg and Slichter. It has been greatly extended by Holcomb and Norberg. Both line width and T_1 are strongly temperature dependent. An application of the theory of Bloembergen, Purcell and Pound and a modification due to Torrey explain the temperature dependence largely as a result of self-diffusion of the nuclei involved. Activation energies E and infinite temperature diffusion constants D_0 may be determined from the resonance studies. For Na, D_0 and E have been determined by Nachtrieb using radioactive tracers. He finds $D_0 = 0{\cdot}24\,\mathrm{cm^2\,sec^{-1}}$, $E = 10{\cdot}4$ kcal. The resonance data gives $D_0 = 0{\cdot}36\,\mathrm{cm^2\,sec^{-1}}$, $E = 10{\cdot}4$ kcal. For Li four independent aspects of the resonance data can be used to determine the single parameter E and give $E = 13{\cdot}2$ kcal. For Li it is found that $D_0 = 0{\cdot}23\,\mathrm{cm^2\,sec^{-1}}$. The interpretation of the Rb data in terms of diffusion is not clear cut. A.

539.11 : 537.311.33

6337. Theory of donor states in silicon. W. KOHN AND J. M. LUTTINGER. *Phys. Rev.*, **98**, *No.* 4, 915–22 (*May*, 1955).

By using the recently measured effective masses for n-type Si, $m_1 = 0{\cdot}98\ m$ and $m_2 = 0{\cdot}19\ m$, approximate solutions of the resulting effective-mass Schrödinger equation are obtained. The accuracy of the solutions was tested in the limiting cases where $m_2/m_1 = 1$ and 0 respectively. The nature of the resulting states and their degeneracy is discussed in some detail, taking into account the fact that the conduction band of Si has six equivalent minima. Experimentally measured ionization energies show that the effective mass theory is seriously in error in the case of the ground state. This error is attributed to failure of the effective mass theory near the donor nucleus, and allowance for this failure is made in the case of higher states. This leads finally to a theoretical spectrum for the electrons bound by P, As or Sb donors. A.

539.11

6338. Density of states curve for nickel. G. F. KOSTER. *Phys. Rev.*, **98**, *No.* 4, 901–2 (*May* 15, 1955).

A density of states curve for the d bands in nickel is presented. This curve is an extension over the entire energy range of the d bands of the density of states curve for nickel already computed by Fletcher and Wohlfarth. The matrix of the interaction of the d states with the periodic potential is exactly the same as was used by Fletcher and Wohlfarth. A.

539.11

6339. Note on the network approximation in metals. A. RAYCHAUDHURI. Note in *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 5, 439–41 (*May*, 1955).

See Abstr. 9433 (1954). It is shown that the use of non-constant potentials does not change the general nature of the results. E. H. SONDHEIMER

539.11

6340. Plasma oscillations and energy loss of charged particles in solids. H. FRÖHLICH AND H. PELZER. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 6, 525–9 (*June*, 1955).

It is shown that the frequencies of longitudinal electric oscillations in solids satisfy the condition $\epsilon(\omega) = 0$, where $\epsilon(\omega)$ is the dielectric constant for the frequency $\omega/2\pi$ which can be obtained from the optical constants n, κ. Such longitudinal waves include so-called plasma oscillations. It is shown that energy losses of fast-charged particles in discrete steps $\hbar\omega_p$ (the plasma quantum) can be expected only if the quantity $n\kappa/(n^2 + \kappa^2)^2$ has a sharp maximum at a frequency ω_p. This holds for the alkali metals and for silver. A.

539.11

6341. Plasma oscillations in metals. E. N. ADAMS. *Phys. Rev.*, **98**, *No.* 4, 947–53 (*May* 15, 1955).

The self-consistent field treatment of the electronic wave-functions of a solid is used as a basis for a theory of plasma oscillations in a metal. Two procedures are used to calculate the plasma frequency, both being based on the Bohm and Pines method of introducing the plasma oscillators. It is found that band-to-band virtual transitions have a strong effect on the plasma oscillations in a metal. It is concluded that the effective mass treatments are not adequate to treat the electron-plasma interaction, except perhaps in certain semiconductors. A.

539.11

6342. Interpolation scheme for energy bands in solids. L. C. ALLEN. *Phys. Rev.*, **98**, *No.* 4, 993–6 (*May* 15, 1955).

The orthogonalized plane wave method is formulated as an interpolation scheme for use in conjunction with calculations made at symmetry points in the Brillouin zone. The Fourier coefficients of the crystal potential and the matrix components of the Hamiltonian between core functions are treated as parameters to be fitted to other calculations made at symmetry points by such methods as the cellular, orthogonalized plane wave, and augmented plane wave. The interpolation scheme then provides a method for making calculations at a general point in the Brillouin zone. The scheme is most useful for the case of valence and excited states where the wave-function on one centre overlaps many of its neighbours. A.

539.11 : 548.7

6343. Madelung energy of cuprous sulphide β-Cu_2S. S. Kobayasi. *J. Sci. Hiroshima Univ. A*, **18**, *No.* 1, 83–6 (*June*, 1954).

The β-phase (110–470°c) of Cu_2S has been found experimentally to show interesting peculiar properties, but the crystal structure of this substance has not yet been determined with sufficient accuracy. The structure and the corresponding cohesive energy were calculated by taking account of both the ionic radii of Cu^+ and S^{--} ions and the symmetry properties of this crystal, in which the Madelung energy of each ion was calculated by the method of H. M. Evjen, after verification of the convergency of this method in the crystal structure. The latter part of the calculation is described. A.

MOLECULES 539.13

539.13

6344. On the treatment of two-centre exchange integrals. H. Preuss. *Z. Naturforsch.*, **10a**, *No.* 3, 211–15 (1955) In German.

A new technique is suggested suitable for computation by electronic machines. A numerical connection between exchange and simpler integrals is emphasized; but reference is only made to 1*s*, 2*s* and 2*p* atomic functions. J. JACOBS

539.13 : 533.7

Argon and methane exp: six potential force constants. *See Abstr.* 5939

539.13 : 539.132

6345. Studies of the interaction between stable molecules and atoms. I. A molecular orbital theory of the activation energy between molecules and atoms. V. Griffing. *J. chem. Phys.*, **23**, *No.* 6, 1015–23 (*June*, 1955).

The molecular orbital method of calculation is applied to the interaction between closed-shell species; the results discussed in this and the following papers of this series indicate that this method will yield quantitative results for energies of a system as function of internuclear parameters if one is interested in the differences in energy for two different geometric ground state configurations of the system. The molecular orbitals are used as a basis of constructing correlation diagrams for predicting mechanisms and calculating activation energies for chemical reactions. The orbitals of the reactants and products are correlated with the orbitals of a state defined as the ambivalent complex. The low-lying excited states of the interacting molecules seem to be of importance in determining the activation energy of a chemical reaction. Considerable qualitative insight into the activation process is gained by this method; the relative values of the activation energies for the interaction between two closed-shell molecules, a molecule and a radical, and two radicals are predicted in agreement with experiment. A.

539.13 : 539.132

6346. Studies of the interaction between stable molecules and atoms. II. Interaction between two He atoms. V. Griffing and J. F. Wehner. *J. chem. Phys.*, **23**, *No.* 6, 1024–8 (*June*, 1955).

The repulsive energy of two helium atoms has been calculated using molecular orbital theory. The equations of Roothaan were used to break down the energy into integrals involving atomic orbitals. The necessary integrals are tabulated in the literature for a wide range of parameter which enabled the potential energy curve to be calculated from $R = 0{\cdot}6$ to $7{\cdot}0\ a_0$. The Slater (1*s*) orbital with effective nuclear charge $Z = 27/16$ was used. The potential curve is lower at all distances from those of other investigators in the range where van der Waals forces give attraction although the curves agree at closer distances. Ionization energies have been calculated over these distances and extrapolated to infinity to give a value which is much better than that calculated with the same orbital by ordinary means. The addition of $2p\sigma$ character to the molecular orbitals by constructing hybrid orbitals of the type $N\{(1s) + \lambda(2p\sigma)\}$ and the determination of λ by a SCF calculation according to the scheme of Roothaan, gives an attractive energy of $2{\cdot}14\times10^{-5}$ a.u. with $\lambda = 1{\cdot}4\times10^{-3}$ at $R = 3{\cdot}11$ Å. Experimental values are approximately 3×10^{-5} a.u. The calculated results are compared with experimental data in the exchange and van der Waals region of the values of the internuclear parameter. A.

539.13 : 539.132

6347. Studies of the interaction between stable molecules and atoms. III. A molecular orbital treatment of the quadratic form of H_4. V. Griffing and A. Maček. *J. chem. Phys.*, **23**, *No.* 6, 1029–34 (*June*, 1955).

Molecular orbital calculations of the quadratic arrangement of four hydrogen atoms have been carried out as a function of the internuclear distance. It is shown that the complex has orbital degeneracy in the ground state. An approximation, which includes the lowest orbital and the degenerate orbitals only, yields a triplet and three singlet states, the triplet being the lowest one in accordance with Hund's rule. The actual calculations show that the quadratic H_4 is unstable with respect to a totally symmetrical displacement at all points of the potential energy surface. A.

539.13 : 539.132

6348. Studies of the interaction between stable molecules and atoms. IV. The energy of the linear H_4 complex. V. Griffing and J. T. Vanderslice. *J. chem. Phys.*, **23**, *No.* 6, 1035–8 (*June*, 1955).

Roothaan's LCAO–SCF treatment has been applied to the linear symmetrical H_4 complex in an attempt to test this method for calculating the energies of activated complexes. Calculations have been made for internuclear distances of 1·4, 1·6, 2·0 and 2·2 a.u. The SCF method gives a lower value for the energy of 1·4 a.u. than was obtained by a simple molecular orbital method without configuration interaction, but gives a higher value than the best configuration interaction treatment. The values of the energies that were obtained are −55·48, −55·99, −56·50 and −56·54 eV at distances of 1·4, 1·6, 2·0, 2·2 a.u., respectively. The changes in the wave-functions as one adiabatically changes the internuclear distance are of particular interest. Although the results cannot be directly compared with experiment, reasonable values for the

energy are obtained indicating that the molecular orbital SCF method with a limited amount of configuration interaction is a promising method for treating closed-shell molecules and interactions between such molecules for small values of the internuclear parameters. A.

539.13 : 539.132

6349. Studies of the interaction between stable molecules and atoms. V. Molecular orbital approach to the H + H_2 reaction. V. GRIFFING AND J. T. VANDERSLICE. *J. chem. Phys.*, **23**, *No.* 6, 1039–42 (*June*, 1955).

In an attempt to find a relatively simple way of calculating activation energies for chemical reactions, Roothaan's LCAO-SCF method has been applied to the linear H_3 complex. Since Roothaan's method has been developed for closed shells, a self-consistent field. treatment has been done on the linear H_3^- complex According to Roothaan, the energy of the H_3 should be equal to a first approximation to the energy of the H_3^- minus the energy required to remove one electron. Calculations have been made at distances ranging from 1·4 to 2·5 atomic units and for various values of the screening constant. Correlation diagrams for the reaction H + H_2 have been constructed and the activation energy calculated. The method gives considerable insight into charge distribution but is unsatisfactory for calculating good energy values. The results are compared with experiment and with values calculated by the MO-configuration interaction method which yields a value of 8·76 kcal/mole. A.

539.13 : 541.124

6350. Method of calculating cross sections for molecular collisions. E. BAUER. *J. chem. Phys.*, **23**, *No.* 6, 1087–94 (*June*, 1955).

The calculation of cross-sections for slow inelastic collisions of molecules, such as occur in chemical reactions, shows an interesting combination of classical and quantum-mechanical features. The de Broglie wavelength is small compared with the range of the intermolecular potential so that there exists a relatively well-defined quasi-classical orbit; but in some cases the coupling constant is small compared with unity, and this gives the problem certain quantum-mechanical characteristics. On account of the condition relating to the de Broglie wavelength, a calculation of the total collision cross-section requires the knowledge of the partial waves for a large number of values of the angular momentum lh. A method is devised to suit these different features. The WKB method lends itself well to this application, with a quasi-classical amplitude and a quantum-mechanical phase for the wave-function. The concept of an impact parameter b is used rather than the orbital quantum number l: this is well suited to describing a quasi-classical orbit, and hence for calculating the total cross-section in a case like the present one. As an example of the method, the cross-section for excitation of the first vibrational state of a hydrogen molecule resulting from collision with another hydrogen molecule is calculated. A.

539.132

6351. On the electron affinity of oxygen. H. SCHÜLER AND W. BINGEL. Note in *Z. Naturforsch.*, **10a**, *No.* 3, 250–1 (1955) In German.

Further experiments with different light sources indicate that previous spectroscopic data [Abstr. 7290 (1954)] refer to the OH^- molecule rather than to OH [Abstr. 7613 (1954)]. In connection with other data this then leads to an electron affinity of oxygen of 1 eV rather than the value 2·2–2·3 eV which is usually given. G. E. BROWN

539.132

6352. Thermodynamic functions for silane. A. P. ALTSHULLER. Letter in *J. chem. Phys.*, **23**, *No.* 4, 761 (*April*, 1955).

As the Si–H interatomic distance is now known, all data necessary for the calculation of the thermodynamic functions C_p^0, $(H^0-H_0^0)T$, $-(F^0-H_0^0)/T$ and S^0 of SiH_4 are available. These were calculated over a range of temperatures from 200 to 1 500°K. The values of $(F^0-H_0^0)T$ and S^0 are somewhat uncertain ($\pm 0{\cdot}04$ cal/deg. mole^{-1}) owing to the large possible error in the value for the moment of inertia. In the other values the error is not larger than 0·1 cal/deg. mole^{-1}. A. J. TAYLOR

539.132

6353. O—O bond dissociation energies in propionyl and butyryl peroxides. A. REMBAUM AND M. SZWARC. *J. chem. Phys.*, **23**, *No.* 5, 909–13 (*May*, 1955).

The kinetics of the decomposition of gaseous propionyl and butyryl peroxides was studied in a flow system. It was found that both compounds decompose in a unimolecular manner. The rate constant for the decomposition of propionyl peroxide is given by the equation $k = 2{\cdot}5\times10^{14}\ \exp(-30\,000/RT)$, and that for butyryl peroxide by the equation $k = 1{\cdot}9\times10^{14}\ \exp(-29\,600/RT)$. It is concluded that

$$D(C_2H_5.CO.O-O.CO.C_2H_5) \simeq D(C_3H_7.CO.O-O.CO.C_3H_7) \simeq 30\,\text{kcal/mole}.$$

The fates of the ethyl and propyl radicals produced in the decomposition are discussed. A.

539.132

6354. On the approximate calculation of oscillator strengths and the effective cross-section for photo-ionization. L. A. VAĬNSHTEĬN AND B. M. YAVORSKIĬ. *Zh. éksper. teor. Fiz.*, **27**, *No.* 6(12), 712–18 (1954) In Russian.

Describes the use of approximate radial functions to calculate transition probabilities and hence oscillator strengths and cross-sections for photo-ionization. Calculations have been made for several cases and for most there is good agreement with experiment.

J. M. HOUGH

539.132

6355. Angular momentum in the Thomas–Fermi model of diatomic homonuclear molecules. J. V. BONET AND A. V. BUSHKOVITCH. *An. Real Soc. Españ. Fis. Quim.*, **51(A)**, *No.* 3–4, 91–8 (*March–April*, 1955) In Spanish.

The Thomas–Fermi method is employed to obtain distribution functions of the electronic angular momentum and of its square for diatomic homonuclear molecules. The mean and the mean square of the angular momentum is defined in terms of the corresponding distribution functions. The mean square angular momentum of the free neutral molecule of nitrogen, N_2, is then calculated, as well as the small

paramagnetic term which appears in the quantum-mechanical formula of the molar magnetic susceptibility for nitrogen gas. A.

539.132

6356. Lowest singlet excited levels of naphthalene. II. R. LEFEBVRE AND C. M. MOSER. Letter in *J. chem. Phys.*, **23**, *No.* 4, 754–5 (*April*, 1955).

For Pt I, see Abstr. 5563 (1955). Points out certain relations between different semi-empirical approximation methods [Abstr. 4352, 11307 (1954)] for treating these levels. J. HAWGOOD

539.132

6357. Spectra and electronic structure of fluorochromate ion, chromyl chloride, and some related compounds. L. HELMHOLZ, H. BRENNAN AND M. WOLFSBERG. *J. chem. Phys.*, **23**, *No.* 5, 853–8 (*May*, 1955).

A semiempirical treatment, which gives satisfactory agreement between calculated and observed spectra for chromate and permanganate ions, has been employed to calculate the excited-state energies and transition moments for the related molecules of the chemical formulae CrO_3X^- and CrO_2X_2. The results show agreement with experimental data which unfortunately are not extensive for these molecules. The calculations indicate an absorption for SO_2Cl_2 in the farther ultraviolet in agreement with experiment. The qualitative significance of the results, so far as the relative importance of σ- and π-bonding is discussed. A.

539.132

6358. Contribution of overlap integral to nuclear quadrupole coupling. K. TSUKADA. Note in *J. Phys. Soc. Japan*, **9**, *No.* 5, 872–3 (*Sept.–Oct.*, 1954).

Interpretation of the quadrupole couplings in solid Br_2 and I_2 requires the inclusion of overlap terms, $S^2 \sim 0{\cdot}1$, to account for the reduction below values predicted using atomic couplings. D. H. WHIFFEN

539.132

6359. Cosine interaction in CsF and RbF. G. BEMSKI, W. A. NIERENBERG AND H. B. SILSBEE. *Phys. Rev.*, **98**, *No.* 2, 470–3 (*April* 15, 1955).

A series of measurements of the line shape of the fluorine resonance *v.* magnetic field have been made using a molecular-beam apparatus. Good theoretical agreement has been found for RbF. The CsF behaviour is complicated by the overlapping Cs spectrum. The equivalent field at the fluorine nucleus per unit molecular rotation, H_r, is found to be $2{\cdot}28 \pm 0{\cdot}20$ gauss and $3{\cdot}00 \pm 0{\cdot}15$ gauss for RbF and CsF respectively. These results are less than those previously measured. A.

539.132 : 534.321.9 : 538.222

Resonance absorption of ultrasound in paramagnetic salts. *See Abstr.* 6306

539.132

6360. Calculation of perturbations in certain molecular electronic terms. II. $^2\Pi-{}^4\Sigma$, $^2\Pi-{}^4\Pi$, $^4\Sigma-\Pi^4$ and $^4\Pi-\Pi^4$ perturbations. D. PREMASWARUP. *Indian J. Phys.*, **28**, *No.* 12, 581–7 (*Dec.*, 1954).

For Pt I, see Abstr. 11278 (1954). Theoretical expressions for the course of the perturbed energy values in the perturbation cases $^2\Pi-{}^4\Sigma$, $^2\Pi-{}^4\Pi$, $^4\Sigma-{}^4\Pi$ and $^4\Pi-{}^4\Pi$ are evaluated. Graphical representations of these perturbation schemes are also given. A.

539.132

6361. Investigation of a new quantum-mechanical method of approximation. R. PAUNCZ. *Acta phys.* [*Hungar.*] **4**, *No.* 3, 237–53 (1955).

Moffitt's quantum-chemical approximate method was investigated for the case of a simple model compound (H_2-molecule). The application of Moffitt's correction to a weaker approximate function gives good results; however, the use of a more correct approximate function which corresponds to the basic idea of the method, gives a much worse result. No decisive conclusion can be drawn regarding the method; the example, however, shows that the results obtained by the method must be regarded with some caution. On the basis of the calculations it was evident that the use of a more correct ionic function gives a much weaker result, thus it is not correct to interpret the ground state of the H_2 molecule as a superposition of homopolar and ionic states. A.

539.132

6362. Diagrams of symmetric triatomic molecules. A. LAFORGUE. *Cahiers de Phys.*, *No.* 53, 9–26 (*Jan.*, 1955) In French.

The molecules H_3 and H_3^+ are used as illustrations of a method of relating the quantities appearing in molecular diagrams to quantum-mechanical observables. The significance of molecular orbitals emerges from consideration of the equations connecting the wave-functions of the ASMO method to those of the VB and spin-states methods. The physical significance of the formalism is discussed. A justification is given of the usual representation of ionization. Terms neglected in the usual molecular diagrams are elucidated, in particular the polarity of weakly polar systems. A. J. TAYLOR

539.132

6363. The electronic structure of hydrogen fluoride. A. B. F. DUNCAN. *J. Amer. Chem. Soc.*, **77**, *No.* 8, 2107–10 (*April* 20, 1955).

A self-consistent field calculation of the normal state of HF in the molecular orbital (MO) approximation is made. The MOs are expressed as linear combinations of all valence and inner shell atomic orbitals of the atoms, and all interactions of the ten electrons are included. The MO functions are used to compute the dissociation energy and dipole moment of the molecule. An equivalent orbital representation is obtained by an orthonormal transformation of the MOs which shows definite directional features of the distribution of electron density. The latter is discussed briefly in connection with the dipole moment and with association in HF. A.

539.132

6364. Dipole velocity and dipole length matrix elements in π electron systems and configuration interaction. M. WOLFSBERG. *J. chem. Phys.*, **23**, *No.* 5, 793–5 (*May*, 1955).

Equations relating dipole velocity and dipole length matrix elements have been tested for π-electron systems treated by a molecular orbital method. Considerable improvement in the validity of the

equations is noted when configuration interaction is included in the calculations. A.

539.132

6365. Electronic structure of metal *bis*-cyclopentadienyls. J. D. DUNITZ AND L. E. ORGEL. *J. chem. Phys.*, **23**, *No.* 5, 954–8 (*May*, 1955).

Molecular orbital theory has been used to describe the electronic structure of ferrocene and related compounds. It is shown that, provided the valence-state promotion energies are considered, the thermochemistry and magnetic properties may be understood. A.

539.132

6366. Note on the dodecahedral σ hybrids. G. GIACOMETTI. Letter in *J. chem. Phys.*, **23**, *No.* 5, 977 (*May*, 1955).

Criticism of work of Higman [Abstr. 3733 (1954)]. No *f* orbital is needed to construct such hybrids. The tables of Kimball (1940) are correct. J. HAWGOOD

539.132

6367. Note on the dodecahedral σ hybrids. B. HIGMAN. Letter in *J. chem. Phys.*, **23**, *No.* 5, 977 (*May*, 1955).

Accepts correction by Giacometti (preceding abstract). J. HAWGOOD

539.132

6368. The electronic structure of an icosahedron of boron atoms. H. C. LONGUET-HIGGINS AND M. DE V. ROBERTS. *Proc. Roy. Soc. A*, **230**, 110–19 (*June* 7, 1955).

The electronic structure of a regular icosahedron of boron atoms is investigated theoretically by the method of molecular orbitals. It is found that thirteen bonding orbitals are available for holding the icosahedron together, besides the twelve outward-pointing equivalent orbitals of the separate atoms. The results are used to interpret the stability of boron carbide, to question a recently proposed crystal structure for elementary boron, and to discuss the chance of existence of a hydride $B_{12}H_{12}$. A.

539.132 : 541.124

6369. Some comments on the frontier orbital theory of the reactions of conjugated molecules. H. H. GREENWOOD. Letter in *J. chem. Phys.*, **23**, *No.* 4, 756–7 (*April*, 1955).

Criticism of this theory as applied to electrophilic and nucleophilic substitution reactions [Abstr. 5235 (1952), 9480 (1954)]. Analysis of the change of π-electron configuration caused by a change $\delta\alpha$ in a Coulomb integral shows that the amplitudes of the frontier MO's, and of all other filled MO's except the lowest, are decreased at the position of attack. The frontier electrons cannot therefore be concerned with the bond formation in these cases. However, in the case of radical substitution, the frontier orbitals are significant. J. HAWGOOD

539.132

6370. The ionization potential and the polarizability of molecules. T. M. REED. III. *J. phys. Chem.*, **59**, *No.* 5, 428–32 (*May*, 1955).

For molecules composed of an atom or a group of atoms completely surrounded by a single species of atoms, *i*, connected by single bonds to the central group, a correlation between the molecule ionization potential I, the molecule polarizability α and the number p_i of the peripheral atoms in the molecule is to be $I\alpha = Ap_i$. A is a constant characteristic of both the kind of peripheral atom and the central group. For $i = H$, A has the same value for the hydrogen in the paraffin hydrocarbons, NH_3 and the methylamines. When the peripheral atoms are of two or more kinds, a relationship of the same form applies if a hypothetical polarizability is used in place of α. This hypothetical polarizability is arbitrarily assumed to be that for the part of the molecule which is directly concerned in the ionization process. A basis from quantum theory is postulated for the correlation found. A.

539.133

6371. Confirmation of the existence of a helium double-molecule. T. KIHARA AND S. KANEKO. Note in *J. Phys. Soc. Japan*, **10**, *No.* 4, 314–15 (*April*, 1955).

An analysis of the second virial coeff. at low temperatures, using a square-well potential, confirms that the 2-body system of He^4 has a discrete energy level. J. JACOBS

539.133

6372. Calculation of the dipole moment of the carbon–hydrogen bond in methane by the Thomas–Fermi method. H. GLAZER AND H. REISS. *J. chem. Phys.*, **23**, *No.* 5, 937–41 (*May*, 1955).

To compute the dipole moment of the CH bond in methane, the pyramids formed by the planes bisecting the HCH bond angles were taken as elements of symmetry. Each pyramid encloses a carbon–hydrogen bond and the four close-pack to form the methane molecule. To simplify the problem, the pyramid was replaced by a cone of equal volume. The Thomas–Fermi equation was solved for the potential within this cone subject to the appropriate boundary conditions, on the IBM Type 701 Electronic Data Processing Machines, using the extrapolated Liebmann method. Boundaries were chosen about each nucleus on which the superposition solution was used. The equation was solved for carbon alone and then for carbon–hydrogen within the cone. The dipole moment was taken as the difference between the two in accordance with views recently expressed by Shull and by Coulson. The value obtained was $2{\cdot}8\,D$ C + H−. The large magnitude is attributed to the poor description of the system by the statistical theory. A.

539.133

6373. The bond lengths of unsaturated hydrocarbons. H. D. DEAS. *Phil. Mag.*, **46**, 670–81 (*June*, 1955).

The standard excited state approximation for an unsaturated hydrocarbon molecule is used to determine the equilibrium configuration of the nuclei of the molecule. Each bond length of the molecule is shown to depend, to an approximation, on a scalar quantity, called bond order, which is characteristic of the bond. This concept of bond order is numerically equal to that of π-bond order used by Coulson and others. The quantum mechanical formulation gives the form of the bond order–bond length relation, but its actual shape is determined from the known bond lengths of naphthalene and anthracene. A.

539.133 : 535.343

Structure of the silane molecule. *See Abstr.* 6001

539.133

6374. Selection rules for normal modes of chain molecules. M. C. TOBIN. *J. chem. Phys.*, **23**, *No.* 5, 891–6 (*May*, 1955).

The selection rules for chain molecules are derived on the basis of the theory of one-dimensional space groups. The selection rules for crystals of polymer chains are discussed and correlated with those of isolated chains. The polyethylene molecule is analysed in detail by these methods and the predictions of the theory compared with experiment. The effects of perturbations on the spectra are discussed. A.

539.133

6375. Statistical computation of mean dimensions of macromolecules. II. F. T. WALL, L. A. HILLER, JR AND W. F. ATCHISON. *J. chem. Phys.*, **23**, *No.* 5, 913–21 (*May*, 1955).

For Pt I, see Abstr. 8510 (1954). Random walks subject to the excluded volume effect have been generated by means of a high-speed electronic digital computer for four different two-dimensional lattices. A semiempirical theory has also been developed for interpreting the statistical data. From the results obtained it is possible to show for several two-dimensional lattices that the quotient, $\langle r_n^2 \rangle_{Av}/n$, diverges as $n \to \infty$, where $\langle r^2 \rangle_{Av}$ is the mean square length of permissible walks of n steps. This conclusion was reached by using an appropriate difference equation in conjunction with data on the mean square lengths of successful walks and the mean square lengths of failures resulting from ring closures. Integration of that difference equation indicates that if n is sufficiently large, $\langle r_n^2 \rangle_{Av}$ is proportional to n^A, where A depends upon the lattice system. A.

539.133 : 539.501

6376. Studies on macromolecules. The spreading properties of rubber and its derivatives. N. H. SIVARAMAKRISHNAN AND M. R. A. RAO. *Indian J. Phys.*, **28**, *No.* 12 (*Dec.*, 1954) = *Proc. Indian Assoc. Cultiv. Sci.*, **37**, 41–9 (*Dec.*, 1954).

The spreading properties of rubber and its derivatives have been studied in detail. The effect of protein content and solvent towards the spreading of rubber has been investigated and it was found that the double bond of the isoprene was responsible for the spreading property of rubber. Attention has been given to the rate of oxidation of rubber films as influenced by the pH and halogens of the aqueous substrate. Moreover, the spreading and other physicochemical properties of chlorinated rubber samples have been compared. A.

539.133

6377. On possible methods of producing active molecules for a molecular generator. N. G. BASOV AND A. M. PROKHOROV. Letter in *Zh. éksper. teor. Fiz.*, **28**, *No.* 2, 249 (1955) In Russian.

Active molecules for low-frequency molecular generators can be obtained by previous radiation with a high-frequency auxiliary field. This causes resonance transitions between different molecular terms.

J. JACOBS

ATOMS . NUCLEUS . ISOTOPES 539.15

539.152.1

6378. The position of the first excitation state in nuclei with even proton and neutron number. P. STÄHELIN. *Dissert. E.T.H. Zürich, Paper* 2557, 44 *pp.* (1953) In German.

A survey shows that the lowest excitation energy of even-even nuclei is a smooth function of the neutron and proton number. In sequences of neighbouring nuclei the excitation energy increases if the number of protons or of neutrons approaches the next magic number. Several nuclei which seemed to disobey this rule were reinvestigated experimentally, and in every case the new data obtained confirm the rule. The 145 keV radiation which accompanies the transmutation of Cl^{34} into S^{34} is an isomeric ($M3$) transition between the known 33 min state and the ground state of Cl^{34}, the half life of which is 1·45 sec. An $O^+ \to O^+$ transition with an ft value of 2700 sec leads directly to the ground state of S^{34}. Two different isotopes of antimony, Sb^{120} and Sb^{116}, have indistinguishable half-lives of (16 ± 2) min. The 1·3 MeV level which previously was attributed to Sn^{120} belongs to Sn^{116}. The 60 min activity, with a γ-ray of 0·70 MeV probably has to be reassigned to mass number 115 (instead of 116). In Hg^{196} a reported γ-ray of 175 keV could not be confirmed, and a new line corresponding to a first level at 426 keV was found, which agrees with these rules. Further experiments deal with Mo^{96}, Zr^{92} and Mo^{92}. The dependence of the lowest excitation energy on the number of protons and neutrons is interpreted in terms of the shell model. It is shown that a strong configurational interaction must be assumed, and that in general the first excited state is due to a simultaneous excitation of the neutron and the proton structure. 60 refs. A.

539.152.1 : 530.145 : 539.18

6379. Proceedings of the 1954 Glasgow Conference on Nuclear and Meson Physics. Edited by E. H. BELLAMY AND R. G. MOORHOUSE. *London and New York: Pergamon Press* (1955) x + 352 *pp.*

For contents of some of the papers, see Abstr. 5863, 5882–3, 6380–3, 6411, 6430, 6434, 6437–8, 6446, 6457, 6462–3, 6486–9.

539.152.1

6380. Survey of nuclear models. J. A. WHEELER. *Nuclear and meson physics* [*Glasgow*] 38–46. See Abstr. 6379 (1955).

The strong coupling model and optical models can be reconciled by arguments of Brueckner [see esp. Abstr. 3957 (1955)] where the effects of strong coupling in the latter model enter in the form of an effective nucleon mass. Collective motion and forbiddenness in α-particle emission are discussed.

G. E. BROWN

539.152.1

6381. A search for new quantum numbers in nuclear configurations. G. RACAH. *Nuclear and meson physics* [*Glasgow*] 126–8. See Abstr. 6379 (1955).

The classification of the states of l^n still contains three running indices α, β, γ. It is desirable to substitute quantum numbers with some physical or

mathematical meaning for these. Preliminary results of this search are reported here. G. E. BROWN

539.152.1

6382. The shell model and β-decay. L. W. NORDHEIM. *Nuclear and meson physics* [*Glasgow*] 185–90. See Abstr. 6379 (1955).

539.152.1

6383. Gamma transitions and the shell model. M. GOLDHABER. *Nuclear and meson physics* [*Glasgow*] 190–6. See Abstr. 6379 (1955).

539.152.1

6384. On the shell model of the atomic nucleus. K. BLEULER AND C. TERREAUX. *Helv. phys. Acta*, **28**, *No.* 2–3, 245–64 (1955) In German.

Within the framework of the shell model the shape of the potential well and the distribution of the nucleons in space are calculated (this leads to the charge distribution). A good agreement is found with the experimental results from high-energy electron scattering. Some questions of the consistency of the model are treated and the charge independence of nuclear forces is tested in a new way. Finally a more detailed 2-dimensional representation of the level scheme of the shell structure is given. A.

539.152.1

6385. Statistical theory of heavy nuclei and nuclear forces. F. I. KLIGMAN. *Zh. éksper. teor. Fiz.*, **28**, *No.* 3, 297–307 (1955) In Russian.

A system of coupled equations is obtained, defining the energy of the nucleus in terms of the density, interaction potential, and various parameters. The radial dependence of the interaction is taken to be a Yukawa potential, $-g^2e^{-\kappa r}/r$, and various exchange operators are employed. With a value of g^2/κ from the deuteron, saturation can be obtained for nuclear radii $R = r_0A^{1/3}$ and reasonable values of r_0. The isotropic dependence of the energy and contributions from non-saturation of spin and charge are obtained, the latter to first order in $\rho = \rho_1 - \rho_2$, where ρ is the spin or charge density. G. E. BROWN

539.152.1

6386. A theory of the apparatus for the observation of nuclear magnetic resonance. H. PFEIFER. *Ann. Phys.* [*Leipzig*] **15**, *No.* 5–6, 311–24 (1955) In German.

A detailed discussion of the signal shapes as a function of relaxation times, voltages applied, coil resistance, etc., for nuclear magnetic resonance using a Bloch type of apparatus. These are compared with those from autodyne circuits for which changes of apparent line shape are possible and with the regenerative oscillator circuits for which the full theory is not feasible. D. H. WHIFFEN

539.152.1

6387. Present state of nuclear models of the individual particle type. C. MARTY. *Cahiers de Phys.*, *No.* 53, 27–37 (*Jan.*, 1955) In French.

A discussion of the regions of validity and the justification for such models. P. T. MATTHEWS

539.152.1

6388. Nuclear potential in a liquid drop model. D. CURIE. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 13, 1417–19 (*March* 28, 1955) In French.

An expression is given for the potential of a single nucleon, in a liquid drop model in which a Yukawa potential is assumed between any two particles. This resembles an oscillator potential rather than a square well. If the radius of nuclear matter is $1{\cdot}2\,A^{1/3}$ then $1{\cdot}4\,A^{1/3}$ is the range of the nuclear potential. P. T. MATTHEWS

539.152.1

6389. Shell theory for the nuclei with mass 19. M. G. REDLICH. Letter in *Phys. Rev.*, **98**, *No.* 1, 199–200 (*April* 1, 1955).

Results of shell model calculations for F, O, Ne, using a central oscillator potential and central Gaussian 2-body forces with parameters similar to those of Abstr. 9497 (1954). There is agreement with 4 out of 7 pieces of experimental data. W. J. SWIATECKI

539.152.1

6390. System of even-even nuclei. G. SCHARFF-GOLDHABER AND J. WENESER. Letter in *Phys. Rev.*, **98**, *No.* 1, 212–14 (*April* 1, 1955).

A detailed analysis shows that the 2nd excited state E_2 of nuclei with $36 \leqslant N \leqslant 88$ have character, 4+, 2+ or 0+ and energies $\sim 2{\cdot}2$ times E_1, in contrast to the rotational bands with $E_2 : E_1 = 3{\cdot}3$ found for $N \geqslant 90$. A possible interpretation is in terms of collective (harmonic) vibrations of the nucleus, treated here in intermediate coupling plus some direct inter-particle forces. W. J. SWIATECKI

539.152.1

6391. On the dilation of the *s* shell of O^{16}. B. JANCOVICI. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 15, 1608–10 (*April* 13, 1955) In French.

A variation calculation of the deformation of the *s* shell due to the *p* nucleons. The radius of the shell is only 5% greater than that of the α-particle. P. T. MATTHEWS

539.152.1

6392. Giant resonance interpretation of the nucleon–nucleus interaction. A. M. LANE, R. G. THOMAS AND E. P. WIGNER. *Phys. Rev.*, **98**, *No.* 3, 693–701 (*May* 1, 1955).

In the consideration of the independent-particle model, a distinction can be made between the spacing D of the levels of the whole nucleus and the spacing d of the levels of individual nucleons. Except in the immediate neighbourhood of the normal state of closed-shell nuclei, $d \gg D$. In the "giant-resonance" interpretation considered here, the deviations from the independent-particle model are strong enough to mix many states of the whole nucleus, but the mixing is restricted to an energy range which is less than the order of d. According to this interpretation, the reduced particle widths of the levels of the compound nucleus are, on the average, anomalously large close to the energy values of those states of the independent-particle model which correspond to an unexcited target nucleus and a virtual level of the incident particle. As a consequence, the nuclear cross-sections have a gross structure which is similar to a giant resonance, such as is implied by the complex square well representation of the nucleon–nucleus interaction. The position, width and height of these maxima in the average cross-sections are expressed in terms of

the parameters of the independent-particle model and the departure of the actual nuclear potential which are responsible for the inaccuracy of this model. It is shown, however, that the conventional nuclear potential gives far too large values for the widths of the giant resonances (that is, for the imaginary part of the presentative complex square well potential). A.

539.152.1 : 539.172.13

6393. On the demonstration of instantaneous sub-structures in the carbon nucleus by energetic nucleons. P. CÜER, A. SAMMAN AND J. COMBE. *C.R. Acad. Sci. [Paris]* **240**, *No.* 14, 1527–9 (*April* 4, 1955) In French.

Ten $C^{12}(p,p')3\alpha$ stars, produced in nuclear emulsions by 340 MeV protons, are analysed. Six are consistent with scattering of the incident proton by an α-particle "sub-structure" of the C^{12} nucleus. J. J. WILKINS

539.152.2

6394. On the nuclear quadrupole moment of La^{139}. G. LÜIRS AND A. STEUDEL. Note in *Naturwissenschaften*, **42**, *No.* 5, 120 (1955) In German.

Measurements of several lines indicate a value much smaller than that given by Murakawa [Abstr. 1564 and 9514 (1954)]. Further measurements are being carried out to determine the value. G. E. BROWN

539.153

6395. High-frequency transitions in the excited $7\,^2P_{3/2}$-state of caesium atoms and the determination of the quadrupole moment of the Cs^{133} nucleus. K. ALTHOFF. *Z. Phys.*, **141**, *No.* 1–2, 33–42 (1955) In German.

Using the depolarization of the fluorescence line as indicator, $F_{2\leftrightarrow 3}$ at 49·90, $F_{3\leftrightarrow 4}$ at 66·45 and $F_{4\leftrightarrow 5}$ at $82{\cdot}85 \pm 0{\cdot}05$ Mc/s were observed, as well as the double quanta transitions $F_{2\leftrightarrow 4}$ at 58·15 and $F_{3\leftrightarrow 5}$ at 74·65 Mc/s. The coupling constants are $A = 16{\cdot}60 \pm 0{\cdot}01$ Mc/s and $B = -0{\cdot}11 \pm 0{\cdot}08$ Mc/s and from the latter $Q(Cs^{133}) = -0{\cdot}003 \pm 0{\cdot}002 \times 10^{-24}\,cm^2$. D. H. WHIFFEN

539.153

6396. Intensity ratios in the high-frequency spectrum of excited atoms measured by the double resonance method. H. KRÜGER. *Z. Phys.*, **141**, *No.* 1–2, 43–8 (1955) In German.

The amount of depolarization of the fluorescent light at r.f. resonance is calculated by introducing the transition probabilities for the Zeeman hyperfine levels of the optical transition $^2S_{1/2} \leftrightarrow {}^2P_{3/2}$ for Cs^{133} and the probabilities for the r.f. transitions $(Fm_F) \leftrightarrow (F'm_{F'})$ in the $^2P_{3/2}$ state. The $F \leftrightarrow F'$, $5 \leftrightarrow 4$ and $3 \leftrightarrow 2$ transitions are more easily saturated than the $4 \leftrightarrow 3$, which is in agreement with experiment with a 3 Oe r.f. field. D. H. WHIFFEN

539.153

6397. General relations between the low atomic configurations l^m, $l^m s$ and $l^m s^2$. M. A. CATALÁN AND M. T. ANTUNES. *An. Real Soc. Espan. Fis. Quim.*, **51**(A), *No.* 1–2, 5–18 (*Jan.–Feb.*, 1955) In Spanish.

The general relations recently found [Abstr. 4852 (1954)] by Catalán, Rohrlich and Shenstone for the d^m, $d^m s$ and $d^m s^2$ configurations are generalized to l^m, $l^m s$ and $l^m s^2$ ($l = 0$, 1, 2 and 3) configurations. Theoretical formulae for the lowest terms of these configurations, in terms of Slater functions, have been deduced for different m- and l-values. The differences between terms, corresponding to configurations which differ only in one electron, have been computed for the simple case in which the functions do not change with m. The calculated values show a very good agreement with the empirical data, the minor differences being due, probably, to the change of functions with m. A.

539.153

6398. Orientation and alignment of sodium atoms by means of polarized resonance radiation. W. B. HAWKINS. *Phys. Rev.*, **98**, *No.* 2, 478–86 (*April* 15, 1955).

Sodium atoms have been oriented by means of circularly polarized resonance radiation. The amount of orientation agrees with that calculated from the intensity of the light source used. The polarization of the light scattered from the sodium sample varies in the expected manner when the light intensity and applied magnetic field are varied. Illumination with unpolarized resonance radiation is shown to result in alignment of the sodium atoms. The largest degree of orientation achieved corresponds to an average value for the nuclear, electronic, and total angular momenta of $\bar{M}_I = 0{\cdot}180 = 0{\cdot}120I$, $\bar{M}_S = 0{\cdot}035 = 0{\cdot}070S$, $\bar{M}_F = 0{\cdot}216 = 0{\cdot}108F$, respectively. A.

539.153

6399. Energies of the ground states of He, Li^+, and O^{6+}. S. CHANDRASEKHAR AND G. HERZBERG. *Phys. Rev.*, **98**, *No.* 4, 1050–4 (*May* 15, 1955).

A complete 14-parameter calculation for the ground state of He and similar 10-parameter calculations for the ground states of Li^+ and O^{6+} have been carried out. In addition, using the four most important of eleven terms, which were tried individually as fifteenth parameters, an 18-parameter calculation for He has been carried out but without minimizing against the scale parameter k. Similar 12-parameter calculations were carried out for Li^+ and O^{6+} using the two most important terms beyond the tenth in the He calculation. As a result, the 18-parameter non-relativistic ionization potential of He is found to be $198311{\cdot}4\,cm^{-1}$ The series of 6, 10, 14, 18 parameter values appears to converge to $198312._3\,cm^{-1}$ with an error of less than $2\,cm^{-1}$. Adding the relativistic corrections yields $198310._4\,cm^{-1}$ which agrees to $0{\cdot}1\,cm^{-1}$ with the latest experimental value. Considering the uncertainties of the theoretical and experimental values, the magnitude of the Lamb shift of the ground state of He (compared to He^+) must be less than $3\,cm^{-1}$ which does not contradict present theoretical estimates. Similar agreements but within wider limits of error are found for the 12-parameter energy values of the ground states of Li^+ and O^{6+}. A.

539.153 : 539.132 : 539.11

6400. One-electron energies of atoms, molecules, and solids. J. C. SLATER. *Phys. Rev.*, **98**, *No.* 4, 1039–45 (*May* 15, 1955).

In the method of the self-consistent field, the one-electron energies of the occupied orbitals agree closely with ionization energies of the corresponding atom or

molecular system. To compare such calculations with experiment, a table of ionization energies of the atoms is needed. Such a table is set up in the present paper. For the outer electrons, optical data are used, the energy of each configuration being used as the weighted mean of all the states in that configuration. For the inner electrons, X-ray data are used, and for this purpose a revised table of X-ray term values is presented. The two sets of values should not agree, for the zero of energy in optical spectra is that for an electron removed an infinite distance from the isolated atom, while in X-ray terms all energies are referred to the Fermi energy in the crystal. For the alkali metals, measurements of both types can be intercompared, and it is shown that for Li the Fermi level lies about 0·8 rydberg, below the zero of energy for the atom, for Na and K about 0·5, and for Rb about 0·4 rydberg. Using this information, appropriate corrections are applied for the other atoms, and a table of ionization energies of the atoms is constructed. The values in this table are compared with experimental information from soft X-ray spectra, and theoretical calculations of energy levels in atoms, molecules and solids. A.

539.153 : 539.18

6401. Energy levels of π^-mesonic atoms. K. A. Brueckner. *Phys. Rev.*, **98**, *No.* 3, 769–71 (*May* 1, 1955).

The shift of the energy levels of the π-mesonic atom which results from the strong nuclear absorption of the meson is estimated and shown to be comparable with the shift associated with the scattering interaction. It is also shown that the level broadening due to the finite lifetime of the meson in the nucleus is almost entirely produced by the absorption process. A.

539.153.4

6402. Helium wave equation. J. H. Bartlett. *Phys. Rev.*, **98**, *No.* 4, 1067–70 (*May* 15, 1955).

The wave-function for the ground state of helium has been obtained by a method which involves iterating in one direction only, the values of the function in any one plane being made mutually consistent by solving 30 simultaneous equations in 30 unknowns. The local energy value $(H\phi)/\phi$ is approximately constant over most of space, the maximum deviations occurring at large distances between electron and nucleus. The present accuracy is not sufficient to give a good determination of the eigenvalue, but it appears to be at least within 0·5% of the experimental value. A.

539.153.4 : 537.531 : 535.33

6403. Computed transition probabilities for X-ray continua of potassium. M. N. Lewis, L. C. Green, M. M. Mulder, P. C. Milner and E. K. Kolchin. *Phys. Rev.*, **98**, *No.* 4, 1020–8 (*May* 15, 1955).

The rate of change of the oscillator strength at the *K*-edge of ionized potassium has been computed in a number of ways and a few computations have been made on the *L*-edge. The work has been carried through by using both hydrogenic and Hartree wave-functions at the level of the single-electron approximation and Hartree and Hartree–Fock wave-functions when the single-electron approximation was not used. Calcium wave-functions both with and without exchange have also been employed. The moment, momentum and acceleration matrix elements have been computed. The momentum matrix element gives values most closely in agreement with experiment and is most stable with respect to changes in the wave-functions. It is followed by the acceleration and the moment in that order. The single electron approximation gives good results. If the single electron approximation is not used, it is essential that exchange effects be included by employing the determinant form of the wave-functions, and the Hartree–Fock one-electron wave-functions then give considerably better results than the ordinary Hartree functions. It also proves to be possible to substitute the wave-functions of the unexcited ion of next higher atomic number, calcium, for the wave-functions of potassium excited in an X-ray level without noticeable deterioration in the results. A.

539.155.1

6404. Isotopic masses. I. $A < 34$. A. H. Wapstra. *Physica*, **21**, *No.* 5, 367–84 (*May*, 1955).

The binding energies and atomic masses are computed for all known nuclei with mass number <34 from nuclear reaction energies. Fair agreement with the most modern mass spectroscopic measurements is obtained by applying a slight change in the energy calibration for nuclear reaction measurements. A.

539.155.1

6405. Isotopic masses. II. $33 < A < 202$. A. H. Wapstra. *Physica*, **21**, *No.* 5, 385–409 (*May*, 1955).

The masses and binding energies of nuclides with mass number between 33 and 202 are computed from mass spectroscopic data in combination with nuclear reaction energies. A.

539.155.1

6406. Isotopic masses. III. $A > 201$. J. R. Huizenga. *Physica*, **21**, *No.* 5, 410–24 (*May*, 1955).

The masses and binding energies of nuclides with mass number greater than 201 are computed from mass spectroscopic data in combination with nuclear disintegration energies. A.

RADIOACTIVITY α-, β- AND γ-RAYS 539.16

539.16/.17

6407. Tables of *X* coefficients. J. M. Kennedy, B. J. Sears and W. T. Sharp. *Atomic Energy Canada Rep.*, *No.* 106, 9 *pp.* (*May*, 1954).

Values of the coefficients in factored form required for the analysis of angular correlation experiments [see Abstr. 5591 (1955)]. 16 pp. tables. M. A. Grace

539.16

6408. Isotope ratio of "ordinary" lead and its interpretation. P. Eberhardt, J. Geiss and F. G. Houtermans. *Z. Phys.*, **141**, *No.* 1–2, 91–102 (1955) In German.

Measurements have been made on the isotope ratio of 60 samples together with data on the U^{238}/Pb^{204} and U/Th ratios of the same minerals. A "model-age"

for these minerals has been calculated from this data and compared with the geological age. Two types, *B*- and *J*-types, of discrepancy have been found. The *B*-types have too large a model age, and this is explained in terms of a remobilization of an earlier mineral. The *J*-type have too small a model age due to mixing with radioactive decay leads; this has been confirmed by measurements on recent samples from Vesuvius. J. M. HOUGH

539.16

6409. Nomogram for radioisotope buildup and decay. J. R. STEHN AND E. F. CLANCY. *Nucleonics*, **13**, *No.* 4, 27 (*April*, 1955).

539.16 : 536.422.15

Twin Knudsen effusion apparatus for small samples of radioactive materials. *See Abstr.* 6079

539.16.08

6410. Quick technique for preparing radioactive reference sources. F. BARREIRA AND M. LUSA MARTINS. *Rev. Fac. Ciênc. Univ. Lisboa B*, **3**, 157–64 (1954) In Portuguese.

The preparation of sources in collodion and ducocement are described, giving values of the ratio: cement/active material. Self-absorption curves and the back scattering effect with Al are shown. The homogeneity of the sources was studied by autoradiography. J. J. PHIPPS

539.16.08

6411. Observation of nuclear events in Glaser bubble chambers. R. H. HILDEBRAND. *Nuclear and meson physics* [*Glasgow*] 311–15. See Abstr. 6379 (1955).

Construction of bubble chambers is discussed. Advantages are noted and means of identification of particles is treated. Ten photographs of events are included. G. E. BROWN

539.16.08

6412. Disintegration-rate determination by 4π-counting. II. Source-mount absorption correction. B. D. PATE AND L. YAFFE. *Canad. J. Chem.*, **33**, *No.* 5, 929–37 (*May*, 1955).

For Pt I, see Abstr. 5593 (1955). The various methods in use for determining the correction for absorption due to the source mount used in a 4π-counter are discussed, and experiments conducted to test the validity of the correction, arising from these methods, for β-emitters of varying end-point energies. The methods all give erroneous corrections for low-energy β-emitters and possible reasons for the errors introduced by the "sandwich method" are discussed. An "absorption curve" type method is proposed which is shown to give more accurate correction factors. A.

539.16.08

6413. The determination of radon concentrations in air. G. COWPER AND S. D. SIMPSON. *Atomic Energy Canada Rep.*, *No.* 78, 6 *pp.* (*May*, 1953).

A high voltage is used to deposit the decay products on a foil in a chamber, and the α-rays from this produce scintillations in a ZnS screen. These latter are measured by a linear amplifier, discriminator and scaler, and concentrations of 10^{-10} c/litre can be determined to an accuracy unaffected by cosmic rays or electrical background, and limited by counting statistics. F. T. FARMER

539.16.08 : 539.164

6414. Disintegration-interval-analysis of radioelements, efficiency of the estimates. D. HIRSCHBERG. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 2, 341–3 (*Feb.*, 1955) In French.

It is concluded that, from a detailed pulse-interval analysis, comparatively little information is obtainable additional to that gained from a simple counting of intervals less than an arbitrary τ [Abstr. 3037 (1955)]. A. O. STANESBY

539.16.08

6415. Loaded nuclear emulsions using glass tubes. J. CATALÁ AND J. CASANOVA. *An. Real Soc. Espan. Fiz. Quím.*, **51**(A), *No.* 3–4, 77–84 (*March–April*, 1955) In Spanish.

Tubes of glass are filled with the solution of the target element. Some details are given of the manufacture of the tubes and of their application to the study of light fragments emitted during the uranium fission when bombarded with slow neutrons. A.

539.163

6416. Decay of ^{103}Ru. H. H. FORSTER AND A. ROSEN. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 972–3 (*May*, 1955).

Beta-ray groups with end points at 128 ± 4 keV (28%), 202 ± 2 keV (70%) and 695 ± 15 keV (~1%) have been identified by β-spectrometer measurements and γ-rays of 55, 498 and 610 keV using a scintillation counter. Additional γ-rays of 297, 323 and 366 keV attributed to transitions between the rotational states (295 and 365 keV) and the ground and 40 keV isomeric states in Rh^{103} were revealed in the photoelectron spectrum using a Pb radiator. M. A. GRACE

539.163

6417. Holmium-167. T. H. HANDLEY, W. S. LYON AND E. L. OLSON. *Phys. Rev.*, **98**, *No.* 3, 688–9 (*May* 1, 1955).

Proton bombardment of Er_2O_3 yielded a holmium activity with a half-life of 3·0 hr. It was found to decay by emitting two β-particles with energies of 1·0 and 0·28 MeV and with γ-rays of 0·35 and 0·70 MeV energy. It was produced by $Er^{170}(p,\alpha)Ho^{167}$ and $Er^{167}(n,p)Ho^{167}$ reactions, and is assigned to Ho^{167}. A.

539.163

6418. The radioactivity of ^{183}Ta, ^{185}Ta, ^{183m}W and ^{185m}W. A. J. POË. *Phil. Mag.*, **46**, 611–20 (*June*, 1955).

The following radiation characteristics of the neutron excess tantalum isotopes Ta^{183} and Ta^{185} and of the isomers W^{183m} and W^{185m} have been determined:

	Ta^{183}	Ta^{185}
Half-life	5·0±0·1 days	49·5±1·5 min
β-energy (MeV)	~0·15, 0·6	~0·15, 1·72
γ-energy (keV)	110, 160, 210, 240, 320	125, 175, 235
	W^{183m}	W^{185m}
Half-life	5·5 sec	1·62±0·05 min
β-energy (MeV)	—	—
γ-energy (keV)	105, 155	130,165

Ta^{185} does not decay to any appreciable extent via the isomer W^{185m} and the 175 keV γ-ray from Ta^{185} is not the same as the 165 keV γ-ray from W^{185m}. The 125 keV γ-ray from Ta^{185} and the 130 keV γ-ray

from W^{185m} are probably the same and due to transition to the ground state of W^{185m}. Unless there is an undetected rate-determining transition the 165 keV γ-ray from W^{185m} is then due to the isomeric transition and from half-life and K conversion considerations it may be classified as $E3$. Similarly the 155 keV γ-ray in W^{183m} is probably from the rate-determining transition. The classification of the W^{183m} isomeric transition type on the basis of K conversion measurements is not unambiguous. A.

539.163.1

6419. Effective half-life of I^{131} in cuprous iodide sources. F. Barreira, M. Laranjeira and M. Lusa Martins. *Rev. Fac. Ciênc. Univ. Lisboa B*, **3**, 165–76 (1954) In Portuguese.

This was found to be 8·1 days in dry sources (37·2 mg/cm³) and no influence of the mode of storage was observed. Dry sources with 0·4 mg/cm³ showed the same half-life. For sources kept in a water-vapour-saturated medium the half-life was shorter because of loss of active material due to volatile oxides of iodine. Sources prepared by direct precipitation on the tray also gave a shorter value.

J. J. PHIPPS

539.163.1

6420. The half life of Tl^{204}. J. Tobailem and J. Robert. Letter in *J. Phys. Radium*, **16**, *No.* 4, 340–1 (*April*, 1955) In French.

Differential ionization chamber measurements made over 45 days show that the ½-life is $4·26 \pm 0·06$ years. M. A. GRACE

539.163.1

6421. Metastable state of short period in Tc^{99}. P. Lehmann and J. Miller. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 14, 1525–7 (*April* 4, 1955) In French.

A half-life $(3·5 \pm 0·3) \times 10^{-9}$ sec is reported for the 180 keV state. J. J. WILKINS

539.163.2

6422. The decay of Ti^{51}. T. Mayer-Kuckuk and H. Daniel. *Z. Naturforsch.*, **10a**, *No.* 2, 168–70 (1955) In German.

In >92% of the decays the emission of a β-ray of energy $E_{max} = 2·13 \pm 0·03$ MeV leads to an excited state of V^{51} at 0·32 MeV. γ-γ coincidence measurements indicated a γ-ray of 0·45–0·7 MeV in coincidence with the 0·32 MeV γ-ray, the intensity of the cascade being $1·5 \pm 0·5$%. A decay scheme is suggested and discussed on the basis of the shell model.

J. HUGHES

539.163.2

6423. The branching ratios of ^{86}Rb and ^{42}K. E. W. Emery and N. Veall. Note in *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 346–7 (*April*, 1955).

The β-ray branching in the decay of these isotopes has been measured by comparing the γ-ray disintegration rate, determined by the ionization-chamber method, with the β-disintegration rate determined by 4π β-ray counting. It was found that γ-radiation is emitted in $8·5 \pm 0·5$% of the disintegrations of Rb^{86} and in $10·8 \pm 0·6$% of those of K^{42}. M. A. GRACE

539.163.2

6424. Decay of Bi^{207}. N. H. Lazar and E. D. Klema. *Phys. Rev.*, **98**, *No.* 3, 710–18 (*May* 1, 1955).

The γ-rays of 8·0 yr Bi^{207} have been studied with single-crystal and coincidence scintillation spectrometers. The measured relative intensities of the 0·570, 1·07 and 1·77 MeV transitions are 1, $0·84 \pm 0·06$ and $0·096 \pm 0·007$, respectively. Upper limits on the intensity of a 2·40 MeV and of a 1·47 MeV γ-ray of 0·05% and 0·2%, respectively, of the 1·77 MeV γ-ray have been obtained. Coincidence spectrometry with the lead K X-rays indicates pure L-electron capture to the 2·34 MeV state and $2·8 \pm 0·3$% K-electron capture to the 0·570 MeV level. Other coincidence measurements agree quantitatively with the proposed decay scheme. The angular correlation of the 1·77–0·570 MeV cascade has been measured and is also in agreement with the proposed decay scheme. A.

539.164.2

6425. On the fine structure in alpha decay. A. Bohr, P. O. Fröman and B. R. Mottelson. *K. Danske Vidensk. Selsk., mat.-fys. Medd.*, **29**, *Paper* 10, 20 *pp.* (1955).

The coupling scheme associated with large nuclear deformations, and appropriate to the very heavy nuclei, suggests that the preferred mode of α-decay involves nucleons in paired orbits. For the even-even nuclei, the strongest transition thus goes to the ground state of the daughter, and the fine structure populates predominantly the rotational band associated with this configuration; for odd-A nuclei, the favoured α-decays populate the rotational band for which the orbit of the last odd nucleon remains unchanged. From this interpretation one also obtains a number of correlations between energies and lifetimes of the favoured α-decays in even-even and odd-A nuclei. Moreover, it is possible to estimate the intensity ratios in the favoured α-decays of odd-A nuclei on the basis of those observed in the even-even nuclei. A.

539.164.2

6426. Some aspects of the theory of α-decay. P. Benoist. *Cahiers de Phys.*, *No.* 53, 45–52 (*Jan.*, 1955) In French.

A brief review.

539.165

6427. Revision of the β-ray spectrum of Bi_{83}^{214}(RaC). R. A. Ricci and G. Trivero. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 717–21 (*April*, 1955).

Scintillation counters were used to study β-γ coincidences in the decay of RaC. By determining the end point of the electron absorption curve it is shown that in addition to the ground state β-transition ($E_{max} = 3·17$ MeV) there is also a β-group ($E_{max} = 2·56 \pm 0·25$ MeV) followed by γ-radiation. M. A. GRACE

539.165

6428. Positrons from ^{25}Al and ^{26m}Al. B. Elbek, B. S. Madsen and O. Nathan. *Phil. Mag.*, **46**, 663–9 (*June*, 1955).

The positron emitters 7·4 sec Al^{25} and 6·6 sec Al^{26m} have been produced by proton capture in Mg^{24} and Mg^{25}. Their subsequent decays have been investigated by means of a magnetic lens spectrometer. The maximum energies were measured as $3·24 \pm 0·03$ MeV for Al^{25} and $3·21 \pm 0·03$ MeV for Al^{26m}. The spectra show no complexities and yield straight Fermi plots down to about 1300 keV. The deviations from linearity at lower energies are probably due

to scattering in the spectrometer. No γ-radiation except annihilation radiation was found. A.

539.165 : 539.166

6429. The decay of ^{51}Ti and the nuclear levels in ^{51}V. M. J. Sterk, R. H. Nussbaum and A. H. Wapstra. *Physica*, **21**, *No.* 5, 441–5 (*May*, 1955).

The decay of 5·8 min Ti^{51} has been investigated by means of β- and γ-scintillation spectrometers combined with coincidence counting. It is found that the main β^--spectrum has a maximum energy of $2{\cdot}17 \pm 0{\cdot}04$ MeV and that it is in coincidence with the well-known 0·325 MeV γ-ray which is also present in the electron capture decay of Cr^{51}. An upper limit of 20% could be set to intensity of a β^--transition between the ground states of Ti^{51} and V^{51}. A $0{\cdot}935 \pm 0{\cdot}015$ MeV γ-ray with an intensity of $6 \pm 2\%$ relative to the 0·325 MeV line is also present in the decay of Ti^{51}. No evidence could be found for a 0·48 MeV level in V^{51}. A level scheme is proposed. A.

539.165 : 539.166 : 539.152.1

6430. Introductory lecture on beta- and gamma-ray transitions. K. Siegbahn. *Nuclear and meson physics* [*Glasgow*] 168–77. See Abstr. 6379 (1955).

A discussion of what information high-accuracy γ-spectroscopy can furnish. Two spectrometers are described briefly. G. E. BROWN

539.165.08

6431. The self-absorption factor for β-rays from radioactive gold, measured by the photographic method. D. T. Elbrus. *Rev. Fac. Sci. Univ. Istanbul C*, **19**, *No.* 4, 291–315 (*Oct.*, 1954) In German.

The activity of gold foils containing Au^{198} was measured as a function of thickness by the photographic method. The self-absorption factors were determined from these activities by three methods and the results agreed within 10%. A graph is given of the factor plotted against foil thickness. D. J. PROWSE

539.165.2

6432. Properties of the neutrino and double β-disintegration. Ya. B. Zel'dovich, S. Yu. Luk'yanov and Ya. A. Smorodinskiĭ. *Uspekhi fiz. Nauk*, **54**, *No.* 3, 361–404 (1954) In Russian.

The article reviews the subject with some completeness, and the list of some 40 references draws modest attention to Soviet work in the field. Following a summary of the generally accepted facts concerning the neutrino the authors discuss neutrino and antineutrino, double β-disintegration, parity of electron and neutrino, probability of double β-disintegration. The discussion of experimental results gives a useful survey of the field of investigations in tabular form. C. R. S. MANDERS

539.165.2

6433. Beta-ray spectra. III. H. Takebe. *Progr. theor. Phys.*, **12**, *No.* 6, 747–57 (*Dec.*, 1954).

For Pt II, see Abstr. 4907 (1954). In the general expression of the correction factor, there appear the integrals which contain the product of the nucleon wave-functions. In this paper these integrals are expressed in terms of the radial integrals, by making use of the *jj* coupling model, and their non-relativistic approximation is discussed. A.

539.165.2

6434. The interaction in β-decay. C. S. Wu. *Nuclear and meson physics* [*Glasgow*] 177–85. See Abstr. 6379 (1955).

Evidence for the existence of Fermi and Gamow-Teller couplings is reviewed. The need for *PS* coupling has disappeared since the spin of RaE has been found to be 1 experimentally, and not zero as supposed. Present evidence favours the existence of *S* and *T* couplings. G. E. BROWN

539.165.2

6435. The coupling constants in the theory of β-decay. B. Stech and J. H. D. Jensen. *Z. Phys.*, **141**, *No.* 1–2, 175–84 (1955) In German.

A discussion of the experimentally ascertained limitations in the choice of the coupling constants. Two *a priori* arguments are given, of which the first leads to the alternatives (*STP*) or (*VA*) (in Konopinski's notation), and the second fixes also the coefficients of these combinations, namely $S-T+P$ and $V-A$. Recent experimental evidence appears to favour the second alternative. L. PINCHERLE

539.165.2

6436. Spin-orbit forces and β-lifetimes of B^{12} and Li^8. B. G. Jancovici. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 840–50 (*May*, 1955) In French.

The unfavoured β-transitions $Li^8 \rightarrow Be^8$ and $B^{12} \rightarrow C^{12}$ are explained by a mixing of supermultiplets in Be^8 and C^{12} through the spin-orbit force. This spin-orbit force can be estimated from the experimental *ft* values. In C^{12}, an effective force $a(\boldsymbol{l}.\boldsymbol{s})$, where $a \sim 5$ MeV, is obtained, in good agreement with the generally admitted numbers. On the other hand, in Be^8, a value $|a\sim|$ 1·6 MeV is obtained. This abnormally low value is discussed. A.

539.166

6437. Delayed angular correlation experiments. H. Albers-Schönberg and E. Heer. *Nuclear and meson physics* [*Glasgow*] 197–200. See Abstr. 6379 (1955).

539.166

6438. Resonance fluorescence in nuclei. F. R. Metzger. *Nuclear and meson physics* [*Glasgow*] 201–5. See Abstr. 6379 (1955).

539.166

6439. On the γ-radiations accompanying the disintegration of As^{77}. H. Langevin. Letter in *J. Phys. Radium*, **16**, *No.* 3, 238–40 (*March*, 1955) In French.

Scintillation spectrometer measurements establish γ-rays of 525, 245, 160 and 86 keV, but no rays between 20 and 80 keV. The 86 and 160 keV rays are not in (prompt) coincidence. J. J. WILKINS

539.166

6440. Directional correlation of the Ti^{46} gamma–gamma cascade. T. Hayashi, M. Kawamura and A. Aoki. *J. Phys. Soc. Japan*, **16**, *No.* 5, 334–6 (*May*, 1955).

The directional correlation of successive γ-rays from Ti^{46} was measured using RCA 5819 photomultiplier tubes with NaI(Tl) scintillation crystals as the detectors. The measurements were made by counting more than 50 000 genuine coincidence counts at each angle. It was found that the successive γ-rays were both quadrupole and the spins of the ground, 1st and 2nd excited state should be 0, 2 and 4, respectively. A.

539.166

6441. Gamma rays from the inelastic scattering of neutrons in aluminium, magnesium, and silver. L. A. RAYBURN, D. L. LAFFERTY AND T. M. HAHN. *Phys. Rev.*, **98**, *No.* 3, 701–4 (*May* 1, 1955).

Monoenergetic neutrons from the $H^2(d,n)He^3$ reaction were used to bombard scatterers each in the form of a ring surrounding an unshielded NaI(Tl) γ-ray spectrometer. The γ-ray spectrum for each scatterer was obtained by subtracting the background counting rate from the counting rate with the scatterer in place. An analysis of the γ-ray spectra yields discrete γ-rays for each scatterer as follows: Al: 0·422*, 0·843, 0·988, 1·69 and 2·10 MeV; Mg: 0·438, 0·555, 0·688, 0·837, 1·00, 1·34, 1·91, 2·08* and 2·44 MeV; Ag: 0·332*, 0·696, 0·795, 1·10, 1·99, 2·13*, 2·32 and 2·54* MeV. The starred γ-ray energies denote those that have not been previously reported. A.

539.166

6442. Yield of high-energy gamma rays from proton capture in Be^9. O. LÖNSJÖ, O. OS AND R. TANGEN. *Phys. Rev.*, **98**, *No.* 3, 727–8 (*May* 1, 1955).

Two yield curves have been taken for γ-rays of energy above 2·5 MeV and 5·6 MeV respectively, with proton energies from 150 keV up to 518 keV. The curve for γ-rays above 2·5 MeV shows a single broad resonance around 330 keV proton energy. After correction for barrier penetration the curve can be fitted by a Breit–Wigner formula with resonance energy 307 keV (corresponding to a level in B^{10} at 6·86 MeV) and with half-width 160 keV. The curve for γ-rays above 5·6 MeV also shows a non-resonant radiation, which consists of more energetic components. A.

539.166 : 539.16.08

6443. Some analytical aspects of gamma spectroscopy. L. SALMON. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. C/M*206, 7 *pp.* (1954).

It is shown that a γ-spectrometer may be used for quantitative estimation of activity using only a single standard of known energy and disintegration rate provided branching ratios, internal conversion factors, etc., are known. Examples show that estimation of simple mixtures may be made without chemical separation. The instrument may thus be used as an aid to radiochemical analysis. A.

539.166.83

6444. Internal conversion in the *L* and *M* subshells. E. L. CHURCH AND J. E. MONAHAN. *Phys. Rev.*, **98**, *No.* 3, 718–23 (*May* 1, 1955).

The relative internal conversion of electric and magnetic transitions in the *L* and *M* subshells has been calculated non-relativistically with neglect of screening. In the approximations employed, the relative conversion coefficients are functions of the parameter $Z^2/\hbar\omega$, where Z is the atomic number, and $\hbar\omega$ the nuclear transition energy. For the *L* shell, these quantities have been evaluated over the entire range of practical interest, while for simplicity, the *M* shell has been considered only for vanishing electron momentum. Results are given for transitions of multipole order 1 through 5. Comparison with existing relativistic calculations and experimental data indicates the essential validity of the results obtained, and allows semiempirical generalizations to be made. It is found that dipole transitions, especially magnetic, convert strongly in the *S* subshells. With increasing multipole order, subshells of successively higher orbital angular momenta are preferred. Electric transitions exhibit comparable conversion in the relativistic doublets, $j = l \pm \frac{1}{2}$, while magnetic transitions convert almost entirely in the $j = l + \frac{1}{2}$ component. The usefulness of these properties in the identification of the character of low-energy transitions in heavy elements is indicated. A.

539.166.83 : 537.533.2

Electrons emitted from metals after irradiation by 1·5 MeV X-rays. *See Abstr.* 6205

539.169

6445. Basic problems in the application of radioactive radiations in measuring technique. N. I. SHTEĬNBOK. *Uspekhi fiz. Nauk*, **54**, *No.* 2, 231–84 (1954) In Russian.

Review article with 80 references covering work of the last five years. Deals with principles of design of ionization apparatus; volt-amp. characteristics; regularity of action of α-ionization chambers; fluctuations of ionization current and determination of necessary quantity of radioactive material; basic types of chamber and their efficiency; measurement and amplification of ionization currents; basic layouts using the chamber, peculiarities and fields of application. Apparatus based on change of properties of a gaseous medium; apparatus based on change of size of chamber or on change of situation of source of radiation relative to chamber; apparatus based on absorption or scattering of β- and γ-rays.

C. R. S. MANDERS

NUCLEAR REACTIONS 539.17

539.17

6446. Some results of magnetic analysis of products of nuclear reactions. W. W. BUECHNER. *Nuclear and meson physics* [*Glasgow*] 52–61. See Abstr. 6379 (1955).

A magnetic spectrograph which allows simultaneous focusing of various energies at different points, where they can be detected by nuclear emulsions, is described. Results of (*dp*) reactions from aluminium and calcium are given. G. E. BROWN

539.172

Nuclear reactions due to cosmic rays. *See also under* "Cosmic rays." Decimal classification 537.591.8

539.172.1

6447. Chlorine 38, 34 ratios from heavy ion bombardments. A. E. SOUCH. Letter in *Phil. Mag.*, **46**, 566–9 (*May*, 1955).

The ratio of Cl^{38} to Cl^{34} produced in interactions between C^{13}, N^{14}, O^{16} and Al^{27} and between N^{14} and Mg has been measured. A semi-circular focusing β-spectrometer of moderate resolution and a charge discriminator of lower resolving power but greater acceptance angle were both used. No Cl^{38} was

observed from the O^{16} reactions, and the Cl^{38}/Cl^{34} ratio was found to be $\frac{1}{8}$ for N^{14} + Al and between $\frac{2}{3}$ and $\frac{1}{4}$ for C^{13} + Al. J. H. FREMLIN

539.172.11

6448. The production of neutrons and protons by the bombardment of boron by low energy alpha-particles. E. S. SHIRE AND R. D. EDGE. *Phil. Mag.*, **46**, 640–51 (*June*, 1955).

The number of neutrons and protons produced in the reactions $B^{10}(\alpha,n)N^{13}$ and $B^{10}(\alpha,p)C^{13}$ at 1·51 MeV bombarding energy have been compared and the ratio of the reduced widths, γ_n^2/γ_p^2, found to be $5{\cdot}7 \pm 0{\cdot}5$. Between 1·4 and 2·4 MeV bombarding energy, the emission of protons is closely similar to that of neutrons, but γ_n^2/γ_p^2 has fallen to a value nearer unity at a resonance at 2·16 MeV. The resonance previously reported [Abstr. 754 (1954)] when B^{11} is bombarded by α-particles of 1·58 MeV energy has been shown to be a doublet and a further resonance for neutron emission, but not proton emission, has been found at 2·05 MeV. A.

539.172.13

6449. Study of the passage of energetic nucleons through the nucleus by the Monte Carlo method. P. CÜER AND J. COMBE. *J. Phys. Radium*, **16**, *No.* 3, 29 S–30 S (*March*, 1955) In French.

Stars produced in photographic emulsion by 340 MeV protons from the Berkeley cyclotron have been studied. The stars were split into two groups: those produced by heavy, and those produced by light nuclei. The angular distributions and the energy distributions of ejected protons of energy greater than 30 MeV were determined for the two groups and for the heavy nuclei stars having 1 or 2 black prongs only. The energy was determined from grain-density measurements, the grain-density *v.* energy curve for each plate being determined from an analysis of *p–p* scattering events caused by the incident protons. The stars were further classified according to the number of protons or neutrons emitted (e.g. *P*; *P*, *N*; *N* or 2*N*; 2*P*, etc.). The results were analysed by the Monte Carlo method and good agreement was obtained for the stars caused by heavy nuclei. To obtain agreement for the light nuclei, however, it was found necessary to postulate a "substructure" of α-particles within the nucleus. D. J. PROWSE

539.172.13

6450. Angular distribution of fission fragments from 22-MeV proton-induced fission of U^{238}, U^{235}, U^{233}, Th^{232}, and Th^{230}. B. L. COHEN, B. L. FERRELL-BRYAN, D. J. COOMBE AND M. K. HULLINGS. *Phys. Rev.*, **98**, *No.* 3, 685–7 (*May* 1, 1955).

Angular distributions were measured and the data fitted to $N(\theta) = a + b\cos^2\theta$ where b ranges from 0·08 to 0·28a. The coefficients for possible "$\cos\theta$" terms (i.e. terms asymmetric about 90 deg) are no larger than 0·01a. In every case, asymmetric fission gives more anisotropic angular distributions than symmetric fission. The anisotropy in symmetric fission is about the same for all target elements; in asymmetric fission, the thorium isotopes have larger anisotropies than the uranium isotopes. Among the latter, the anisotropies are quite similar for U^{238} and U^{235}, but somewhat smaller for U^{233}. Explanations for various aspects of the phenomena are proposed. A.

539.172.13

6451. Absolute magnetic analysis of $F^{19}(p,p')F^{19*}$ reaction. C. R. GOSSETT, G. C. PHILLIPS AND J. T. EISINGER. *Phys. Rev.*, **98**, *No.* 3, 724–7 (*May* 1, 1955).

An annular magnet spectrometer has been used to study groups of protons scattered inelastically from the two lowest excited states of F^{19}. The results of six experiments at bombarding energies between 2·1 and 4·5 MeV indicate an assignment of $110{\cdot}4 \pm 0{\cdot}6$ and $197{\cdot}8 \pm 1{\cdot}2$ keV, respectively, for these levels. No other groups ascribable to F^{19} were observed in the region of excitation up to 730 keV, and no multiplet structure was observed for either of the F^{19} groups. The experiments were capable of detecting proton groups with an intensity with respect to the ground state group of 2%. Doublet separations of 3 keV would have been detected. A.

539.172.13

6452. (p,a) and (p,ab) reactions at 100 MeV. J. W. MEADOWS. *Phys. Rev.*, **98**, *No.* 3, 744–9 (*May* 1, 1955).

Nuclear reactions at energies of the order of 100 MeV and higher are considered as being divided into two independent steps, a knock-on process followed by nucleon evaporation. The effect of the knock-on process is evaluated by a method similar to that of Goldberger, while the evaporation process is treated in the usual way. Cross-sections for several (p,n), $(p,2n)$, (p,pn) and $(p,2p)$ reactions on intermediate nuclei are calculated and compared with experimental results. A.

539.172.13

6453. Deuteron pick up by high-energy polarized protons. B. J. MALENKA. Letter in *Phys. Rev.*, **98**, *No.* 3, 843–4 (*May* 1, 1955).

A rough calculation is made of the asymmetry of the final deuterons due to pickup by polarized protons. This shows that measurement of the sign of the asymmetry would be sufficient to distinguish between neutron capture from $j = l + \frac{1}{2}$ or $j = l - \frac{1}{2}$ states. P. T. MATTHEWS

539.172.13

6454. The nuclear interactions produced in carbon, nitrogen and oxygen by 140 MeV protons. H. MUIRHEAD AND W. G. V. ROSSER. *Phil. Mag.*, **46**, 652–62 (*June*, 1955).

A comparison is made between the nuclear disintegrations produced in carbon, nitrogen and oxygen by 140 MeV protons, and the nature of the disintegrations expected from the Goldberger model [Abstr. 1178 (1949)]. A.

539.172.13

6455. Nuclear interactions of 950 MeV protons. W. O. LOCK, P. V. MARCH, H. MUIRHEAD AND W. G. V. ROSSER. *Proc. Roy. Soc. A*, **230**, *No.* 1181, 215–22 (*June* 21, 1955).

Ilford G5 emulsions have been exposed to the 950 MeV beam of the Birmingham proton synchrotron. A mean free path for nuclear interaction of $37{\cdot}0 \pm 2{\cdot}3$ cm was obtained. The disintegrations were separated into those occurring in the light (carbon, nitrogen and oxygen) and heavy (silver and bromine) nuclei of the emulsions, and the mean cross-sections for star production were estimated to be 200 ± 50 and $1\,100 \pm 120$ mb, respectively. The

results have been used to calculate the value of the constant r_0 in the expression for the nuclear radius $R = r_0 A^{\frac{1}{3}}$ and a value of $1{\cdot}30 \pm 0{\cdot}05 \times 10^{-13}$ cm was obtained. The possible effects of meson production are discussed; it is shown that the results are consistent with the assumption of a probability for meson production of approximately 0·6 per star. A.

539.172.13

6456. Nuclear interactions of 600 MeV protons. W. O. Lock and P. V. March. *Proc. Roy. Soc. A*, **230**, *No.* 1181, 222–4 (*June* 21, 1955).

Ilford G5 emulsions have been exposed to 600 MeV protons emerging from the Birmingham synchrotron. A mean free path for nuclear interaction of $33{\cdot}7^{+3{\cdot}0}_{-2{\cdot}7}$ cm was obtained. The size distribution of the stars is given and compared with that obtained with 400 and 1 000 MeV protons incident on emulsion. A.

539.172.13

6457. Nuclear data from deuteron stripping. J. R. Holt. *Nuclear and meson physics* [*Glasgow*] 62–4. See Abstr. 6379 (1955).

Cases which do not conform to the stripping pattern are mentioned. New (*dp*) and (*dn*) experimental results are described. G. E. BROWN

539.172.13

6458. Nomograph for angular distributions in stripping reactions. C. R. Lubitz and W. C. Parkinson. Letter in *Rev. sci. Instrum.*, **26**, *No.* 4, 400–1 (*April*, 1955).

An account of nomographs which are available for the analysis of these reactions. M. A. GRACE

539.172.13

6459. Nuclear energy levels of Be^8 from $Li^7(d,n)Be^8$. M. A. Ihsan. *Phys. Rev.*, **98**, *No.* 3, 689–90 (*May*, 1955).

The nuclear energy levels of Be^8 have been investigated by observing the neutron groups emitted when an isotopic target of Li^7 is bombarded by 0·7 MeV deuterons. Evidence of levels in Be^8 was found at 2·98 and 7·53 MeV, and of a probable level at 5·30 MeV. A.

539.172.13

6460. Calculation of reduced widths from stripping curves. J. E. Bowcock. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 6, 512–20 (*June*, 1955).

A method of calculating the reduced widths of bound states of light nuclei from stripping curves is described. It is essentially a comparison between the experimental curve and the theoretical curve due to Butler. The comparison is done in such a way as to allow for some of the factors neglected in the Butler theory, in particular the type of proton–nucleus interaction included in Horowitz and Messiah's theory [Abstr. 3840 (1954)]. A.

539.172.3

6461. Note on the angular distribution of photo-reaction. M. Morita, A. Sugie and S. Yoshida. *Progr. theor. Phys.*, **12**, *No.* 6, 713–22 (*Dec.*, 1954).

General formulae for the angular distribution of photo-reactions are obtained in a similar way to the case of particle reactions. Expressions thus obtained are more convenient in practical use than that obtained by Simon [Abstr. 1681 (1954)]. A.

539.172.3

6462. Review of photonuclear processes. E. W. Titterton. *Nuclear and meson physics* [*Glasgow*] 141–4. See Abstr. 6379 (1955).

Experimental properties of the giant resonances are reviewed and compared briefly with various theories. In the lower energy region, isotopic spin selection rules are discussed. G. E. BROWN

539.172.3

6463. The giant resonances of nuclear photodisintegration and the shell model. D. H. Wilkinson. *Nuclear and meson physics* [*Glasgow*] 161–7. See Abstr. 6379 (1955).

The large emission of high-energy protons from heavy nuclei after γ-ray absorption is hard to understand if the giant resonance is explained by collective nuclear motions. It is shown that most quantities have the correct order of magnitude if the shell model is used, with a single particle making a transition after absorption of the γ-ray. G. E. BROWN

539.172.3

6464. (γ,α), $(\gamma,n\alpha)$ and (γ,t) reactions on the isotopes Br^{81}, Ag^{109}, K^{39} and O^{16}. J. Schmouker, P. Erdös, P. Jordan and P. Stoll. *J. Phys. Radium*, **16**, *No.* 3, 169–75 (*March*, 1955) In French.

By measurement of induced activities, integrated cross-sections (to 31·5 MeV) have been determined for the reactions $Br^{81}(\gamma,\alpha)$, $Ag^{109}(\gamma,\alpha)$, $K^{39}(\gamma,n\alpha)$, $O^{16}(\gamma,n\alpha)$ and $O^{16}(\gamma,t)$. J. J. WILKINS

539.172.3

6465. Yields of photonuclear reactions with 320-MeV X-rays. II. Interpretation of results. I. Halpern, R. J. Debs, J. T. Eisinger, A. W. Fairhall and H. G. Richter. *Phys. Rev.*, **97**, *No.* 5, 1327–36 (*March* 1, 1955).

It is convenient to separate the yields of radionuclides obtained in Pt I [Abstr. 4067 (1955)] into two groups. The first group consists of the yields of nuclides which are only one or two mass units lighter than the target. All of the yields in this group, and especially those corresponding to (γ,n) reactions, are relatively large. They are due mainly to photons in the giant resonance region ($h\nu \sim 20$ MeV) of the X-ray spectrum, and account for most of the nuclear events produced in medium-weight targets by 320 MeV X-rays. The yields of those radionuclides which are more than a few mass units lighter than the target are in many ways more interesting than the ones in the first group. They are found to exhibit a simple pattern very similar to those obtained in particle-induced high-energy reactions. It is shown that such patterns are at least qualitatively consistent with models of high-energy nuclear reactions in which the last few particles emitted from a struck nucleus, leave by "evaporation." Indeed the evaporation of these last particles exerts so strong an influence on the form of the observed yield pattern, that it becomes very difficult to say anything about either the nature of the original nuclear events or the emission of the first few particles on the basis of a study of yield patterns. Finally, a rough quantitative comparison is made of the yields of radionuclides and the reported yields of

neutrons and other particles emitted from medium-weight nuclei irradiated with 320 MeV X-rays. A.

539.172.3

6466. Photodisintegration of the deuteron by 95-MeV bremsstrahlung. L. ALLEN, JR. *Phys. Rev.*, **98**, *No.* 3, 705–10 (*May* 1, 1955).

Photoprotons produced by irradiating deuterium gas with betatron X-rays have been detected with stacks of unsupported Ilford emulsions. The differential cross-section was determined for photon energies between 20 and 65 MeV and for seven angles of proton emission. The observed angular distributions are well fitted by $f(\theta) = (\alpha + \sin^2\theta)(1 + 2\beta\cos\theta)$. The experimental results for angular distribution and total cross-section have been compared with theoretical predictions assuming a purely central force. Striking departures from the central force theory are observed as the photon energy increases from 20 MeV. A.

539.172.3

6467. Fine structure in the (γ,p) reaction in oxygen. W. E. STEPHENS, A. K. MANN, B. J. PATTON AND E. J. WINHOLD. Letter in *Phys. Rev.*, **98**, *No.* 3, 839 (*May* 1, 1955).

An oxygen gas target was irradiated with 25 MeV bremsstrahlung, and several photoproton groups were detected in nuclear emulsions. The nature of the O^{16} and N^{15} levels involved is discussed. J. J. WILKINS

539.172.4

6468. Nuclear isomerism in Se^{81}. Analysis of the ratios of the effective capture cross-sections as a function of the energy of the incident neutron. P. C. CAPRON AND E. H. CRÈVECŒUR. *Bull. Acad. Roy. Belgique Cl. Sci.*, **40**, *No.* 11, 1214–23 (1954) In French.

The ratio of the cross-sections for formation of two isomeric states of Se^{81} from Se^{80} was found to vary with the energy of the incident neutrons. A theoretical interpretation, involving the presumed spins of the complex nucleus and of the isomeric states, is attempted. An anomalous 6·2 hr period was observed during the experiment. J. M. CASSELS

539.172.4

6469. Elastic scattering and polarization effects of D–D neutrons on carbon. R. W. MEIER, P. SCHERRER AND G. TRUMPY. *Helv. phys. Acta*, **27**, *No.* 7, 577–612 (1954) In German.

The angular distribution and the azimuthal asymmetry of d–d neutrons elastically scattered by carbon for 9 different energies in the range of 2·4 to 3·65 MeV have been determined. The results, corrected for geometrical resolution, multiple scattering and detector efficiency, are expressed in Racah formalism and analysed analytically in terms of phase shifts. The s-phase is in agreement with hardsphere scattering, whereas the p-phases are split in the whole energy range, p 3/2 being nearly zero. Two resonances at 7·85 MeV ($\Gamma = 0{\cdot}060$ MeV) and 8·23 MeV ($\Gamma = 1{\cdot}20$ MeV) excitation energy, both of $3/2^+$-type, are observed. This is a very unusual case of two strongly interfering levels with equal total angular momentum and equal parity but with a difference in width of a factor of 20. The differential polarization of carbon as a function of angle and energy is calculated with these phase shifts. The general behaviour is a $\sin(2\theta)$—dependence giving a degree of polarization P_2 not far from 100% near 50 and 130° scattering angle over most of the investigated energy interval. With these results the degree of polarization $P_1(E_D, \Theta)$ of the d–d neutrons can be calculated from the measured azimuthal asymmetry. The angular dependence at a mean energy of $E_D = 600$ keV is expressed by $P_1(\Theta) = [-(0{\cdot}165 \pm 0{\cdot}017)\sin(2\Theta)]/[1 + 1{\cdot}15\cos^2\Theta + 0{\cdot}75\cos^4\Theta]$, with maximum values $P_{max} = (10{\cdot}8 \pm 1{\cdot}2)\%$ at angles $\Theta = 58°$ and $\Theta = 122°$ in the centre-of-mass system. The sign is in agreement with the sign of the proton polarization of the competing reaction $D(d, p)T$. A.

539.172.4

6470. Differential elastic scattering cross section for neutrons on nitrogen. J. L. FOWLER AND C. H. JOHNSON. *Phys. Rev.*, **98**, *No.* 3, 728–36 (*May* 1, 1955).

Two independent methods were used to measure the angular distribution for elastic scattering of neutrons from nitrogen in the neutron energy range from 0·80 to 2·36 MeV. The scattered neutrons were counted directly in order to obtain the absolute differential cross-section at four neutron energies. These curves provide information on the potential scattering for energies below 1·54 MeV. The second technique, which observed the recoil nitrogen nuclei, allowed a study of scattering at the resonances. In this manner parities were established for levels in N^{15} as follows: The 1·120, 1·401, 1·595 and 2·25 MeV levels have odd parity; the 1·779 MeV level has even parity and a tentative assignment of even parity was made for the 1·350 MeV level. J-values associated with resonances at 1·12 and 2·25 MeV were each assigned to be 3/2 rather than the values favoured in the literature. A.

539.172.4

6471. Cross-section for the $O^{16}(n,\alpha)C^{13}$ reaction for fast neutrons. J. SEITZ AND P. HUBER. *Helv. phys. Acta*, **28**, *No.* 2–3, 227–44 (1955) In German.

The cross-section for the reaction $O^{16}(n, \alpha)C^{13}$ as a function of neutron energy was determinated by means of a parallel-plate ionization chamber filled with O_2. A calibrated Hornyak counter was used as a neutron monitor. The counter was calibrated by comparing its efficiency with that of a hydrogen recoil ionization chamber. The variation of cross-section with energy of the oxygen reaction from threshold to $E_n = 4{\cdot}2$ MeV can be ascribed essentially to the change in penetrability of the Coulomb barrier by the outgoing α-particles. For $E_n = 4{\cdot}2$ MeV the cross-section reaches a value of $\sigma_\alpha = 130$ mb. Resonances are observed at $E_n = 3{\cdot}90$ MeV and $E_n = 4{\cdot}05$ MeV. These resonances correspond to excited states of the intermediate nucleus O^{17} at excitation energies of 7·81 and 7·95 MeV, respectively, above the ground state. The loss of neutrons caused by the oxygen reaction in Ra–Be neutron source strength determinations when water is used as a neutron moderator is discussed. A.

539.172.4

6472. Study of the reaction $_{17}Cl^{35}(n_{th},p)_{16}S^{35}$ by special nuclear emulsion of silver chloride. H. BERTHET AND J. ROSSEL. *Helv. phys. Acta*, **28**, *No.* 2–3, 265–96 (1955) In French.

The slow neutron reaction $Cl^{35}(n, p)S^{35}$ has been

studied with a new nuclear emulsion (prepared by Kodak) where all AgBr was replaced by AgCl. Sandwiches of normal (Ilford) and special Cl-emulsions exposed to pile neutrons enable an accurate determination of the total flux through the $N^{14}(n, p)C^{14}$ reaction and allow a direct comparison of the nearly equal Q values of the two processes by fitting Gaussian curves for the two proton groups. The cross-section for Cl was found to be $\sigma = 0{\cdot}30 \pm 0{\cdot}01$ barn. The relative difference of the Q amounts to 3·6% in excellent agreement with the predicted Q values both from the masses and from the limit of β-spectrum. Comparison of the measured ratio $\sigma(n, p)/\sigma(n, \gamma)$ with theoretical predictions shows coincidence of the order of magnitude and favours the value $r_0 = 1{\cdot}3\times10^{-13}$ cm in the expression $R = r_0 A^{1/3}$ for nuclear radius. Using published experimental data on stopping power energy relation for low-energy protons in the elements, a calibration curve in the energy range $100 < E_p < 1\,000$ keV for Ilford emulsion has been established, thus avoiding any questionable use of α-particle values of stopping power. The agreement with measured proton ranges being excellent, the same procedure was applied for a calibration of the Cl emulsion. Finally a discussion of useful precautions in determining cross-sections with nuclear plates based on a careful chemical analysis of the emulsion is presented. A.

539.172.4

6473. Activation cross-sections of sodium and phosphorus. B. GRIMELAND. Letter in *J. nuclear Energy*, **1**, *No.* 3, 231–2 (*Feb.*, 1955).

Values of $0{\cdot}51 \pm 0{\cdot}03$ barn for Na and $0{\cdot}19 \pm 0{\cdot}02$ barn for P were determined by comparing the thermal-neutron-induced activities with that in Au. M. A. GRACE

539.172.4

6474. The thermal neutron activation cross-sections of U^{238} and Th^{232}. V. S. CROCKER. Letter in *J. nuclear Energy*, **1**, *No.* 3, 234 (*Feb.*, 1955).

These were measured as $2{\cdot}75 \pm 0{\cdot}10$ barn for U^{238} and $7{\cdot}31 \pm 0{\cdot}12$ barn for Th^{232}, by comparing the β-activity induced in thin foils of these isotopes with that of gold whose activation cross-section is known. M. A. GRACE

539.172.4

6475. High energy neutron reactions and the nuclear optical model. L. C. GOMES AND J. L. LOPES. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 792–9 (*May*, 1955).

Born's approximation is extended to the calculation of reaction and total cross-sections. The results are compared with the experimental data on high-energy neutron induced nuclear reactions under the assumption of a complex square well for the nuclear potential. This varies with the excitation energy but the values adjusted for the total cross-section do not fit the angular distribution of the scattered neutrons. A.

539.172.4

6476. Search for 6–10 day Sr → > 100 day Y in uranium fission. G. HERRMANN AND F. STRASSMANN. *Z. Naturforsch.*, **10a**, *No.* 2, 146–51 (1955) In German.

No evidence was found for this chain in the fission of uranium with slow neutrons, either in the strontium fraction or in the yttrium isolated from the strontium. Results of absorption measurements on the radiations from the 9·7 hr Sr^{91} are in agreement with other workers. The half-life of Sr^{89} was found to be $50{\cdot}5 \pm 0{\cdot}2$ days. J. HUGHES

539.172.4 : 539.163.1

6477. The relative abundances of neodymium and samarium isotopes in the thermal neutron fission of U^{235} and U^{233}. E. A. MELAIKA, M. J. PARKER, J. A. PETRUSKA AND R. H. TOMLINSON. *Canad. J. Chem.*, **33**, *No.* 5, 830–7 (*May*, 1955).

The relative fission yields have been measured with a mass spectrometer for samples of natural U and U^{233} that had been irradiated with moderated neutrons. The cross-sections for neutron capture by Sm^{149} and Sm^{151} have been determined to be $66\,200 \pm 2\,500$ barn and 12 000 barn respectively, relative to the cross-section of a B^{10} monitor. The half-lives of Pm^{147} and Sm^{151} have been evaluated to be $2{\cdot}52 \pm 0{\cdot}08$ yr and ~93 yr, respectively, from Sm fission yield data for samples differing in age by seven years. A.

539.172.4

6478. Spectrum of neutrons from the Saclay pile. M. GALULA, B. JACROT AND F. NETTER. Letter in *J. Phys. Radium*, **16**, *No.* 3, 232–3 (*March*, 1955) In French.

Results of time-of-flight spectrometer measurements are reported. J. J. WILKINS

ATOM AND MOLECULAR BEAMS . MESONS NEUTRONS 539.18

539.18 : 530.145 : 539.152.1

Proceedings of the 1954 Glasgow Conference on Nuclear and Meson Physics. *See Abstr.* 6379

539.18

6479. Report on the Bristol group work on hyperons. M. FRIEDLANDER. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 307 (1954).

See Abstr. 4992, 7762 (1954).

539.18

6480. Report on the cloud-chamber work in some American universities. M. ANNIS. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 314–16 (1954).

A brief review is given of: (i) the data obtained by the M.I.T. group on 40 S-particles (18% show associated γ-rays); (ii) an analysis of 103 charged V-decays by the Cal. Tech. group; and (iii) the result on θ^0-particles obtained by the Indiana group. P. ROTHWELL

539.18

6481. Report on the high pressure cloud-chamber at the Marmolada. G. R. EVANS. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 335–7 (1954).

Concerned chiefly with some preliminary photometric measurements of ionization on the particles from a 23-prong star formed in the gas of the cloud-chamber. P. ROTHWELL

539.18

6482. Report of the Committee on *K*-particles. C. C. DILWORTH, A. MANFREDINI, G. D. ROCHESTER, J. WADDINGTON AND G. T. ZORN. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 433–47 (1954).

An extended nomenclature is suggested for *K*-particles on the basis of the nature of the charged decay product. Detailed measurements on 83 decaying *K*-particles are tabulated. Average mass values obtained by various methods of measurement and according to various phenomenological classifications are compared. No clear conclusions can be drawn from the results though there are certainly unresolved inconsistencies. In addition the data on lifetimes, charge asymmetrics and the evidence for the various suggested decay processes are reviewed.

P. ROTHWELL

539.18

6483. Report of the Committee on charged hyperons. P. ASTBURY, A. BONETTI, M. CECCARELLI, N. DALLAPORTA, C. FRANZINETTI, M. FRIEDLANDER AND G. TOMASINI. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 448–60 (1954).

All the available data on 33 hyperons are tabulated and histograms showing the distribution in energy of the primary stars and the masses of the hyperons are given. The majority of the examples are consistent with the hypothesis of a 2-body decay into a nucleon and a π-meson. Several inconsistent cases, it is suggested, might be due to disintegrations of $\Lambda\pm$ and Y_2^+ particles. Recommendations are made concerning the data that should be supplied whenever a hyperon event is published. P. ROTHWELL

539.18

6484. Report on the Committee on neutral *V*'s. C. CASTAGNOLI, M. FRIEDLANDER, M. MERLIN AND M. TEUCHER. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 461–5 (1954).

Gives a table of the data on 49 Λ^0 decays observed in photographic emulsions. A ratio is given of the number of Λ^0 decays to the number of σ-mesons created and brought to rest in the emulsion stack.

P. ROTHWELL

539.18

6485. Report of the Committee on unstable fragments. M. GRILLI AND R. L. SETTI. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 466–71 (1954).

Complete data on 17 possible examples of the delayed disintegrations of unstable fragments have been tabulated. These include details of the parent stars and of the particles emitted in the fragment disintegrations. The measured energy releases are consistent with the hypothesis that in each case a neutron is replaced by a Λ^0. P. ROTHWELL

539.18

6486. A general survey of π-mesons. H. A. BETHE. *Nuclear and meson physics* [*Glasgow*] 236–44. See Abstr. 6379 (1955).

Experimental results for the phase shifts in π-nucleon scattering are given and compared with those obtained theoretically from the Tamm–Dancoff method. G. E. BROWN

539.18

6487. A general survey of the properties of hyperons and heavy mesons. C. C. BUTLER. *Nuclear and meson physics* [*Glasgow*] 324–31. See Abstr. 6379 (1955).

539.18

6488. Heavy charged mesons. L. LEPRINCE-RINGUET. *Nuclear and meson physics* [*Glasgow*] 335–8. See Abstr. 6379 (1955).

539.18

6489. Theoretical views on the new particles. M. GELL-MANN AND A. PAIS. *Nuclear and meson physics* [*Glasgow*] 342–52. See Abstr. 6379 (1955).

The theory of associated production and isotopic spin selection rules are discussed. Experimental tests of the model of Gell-Mann [Abstr. 1039 (1954)] and of the model of Pais [Abstr. 9939 (1954)] are discussed. G. E. BROWN

539.18

6490. Report on a negative heavy meson event observed at the Pic du Midi. N. C. BARFORD. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 333–4 (1954).

Describes an event which can be interpreted as the capture of a K^--particle according to the interaction: $K^- + P \rightarrow \Lambda^0 + \pi^0$. P. ROTHWELL

539.18

6491. Capture of negative *K* mesons. J. HORNBOSTEL AND E. O. SALANT. Letter in *Phys. Rev.*, **98**, *No.* 1, 218–19 (*April* 1, 1955).

A summary with diagrams of about 10 stars made by K^--mesons (produced by 2·8 MeV protons) and including an unstable heavy-particle prong.

W. J. SWIATECKI

539.18

6492. Analysis of charged hyperons. M. BALDO, G. BELLIBONI, M. CECCARELLI AND B. VITALE. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 289–91 (1954).

Measurements are reported on four hyperons: one decaying at rest, two decaying in flight (one previously reported) and one undergoing nuclear capture with the production of an identified proton (~60 MeV) and two short tracks. The *Q*-values found for the hyperons, assuming decay into a nucleon and a π-meson, are consistent with 115 MeV. P. ROTHWELL

539.18

6493. Observations on charged unstable particles heavier than protons (hyperons). C. CASTAGNOLI, G. CORTINI AND C. FRANZINETTI. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 297–304 (1954).

Measurements on two charged hyperons, one appearing to be the only product of an interaction in the emulsion, are given. The available data on ten hyperons, including these two new cases, are tabulated. Using Bartlett's statistical procedure, an upper limit of $\left(2{\cdot}9\ {}^{+\ 4{\cdot}8}_{-\ 1{\cdot}1}\right)\times 10^{-10}$ sec is deduced for their lifetime. P. ROTHWELL

539.18

6494. A review of anomalous V^0-decays. J. P. ASTBURY. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 317–23 (1954).

Concludes that the published data on V^0-decays is not inconsistent with the hypothesis that the only decays involved are those of Λ^0- and θ^0-particles. Most

of the events exhibiting the largest discrepancies can be interpreted by a decay process: $V_3^0 \rightarrow L^{\pm} + K^{\mp} + \sim 60$ MeV. P. ROTHWELL

539.18

6495. A possible example of decay in flight of a charged hyperon. M. DANYSZ, J. GIERULA AND E. SKRZYPCZAK. *Bull. Acad. Polon. Sci. Cl.* 3, 3, *No.* 1, 21–3 (1955).

A track from a star of type $18 + 11p$ is observed to suddenly change its direction by 22° and its grain-density from 66 to 44 grains per 50μ. The latter rules out the possibility that the event is a single scattering. From grain-density *v.* scattering measurements on 2·5 mm the mass of the primary is $\left(1\,930^{+670}_{-490}\right) m_e$ and on 3 mm the mass of the secondary is $\left(2\,160^{+650}_{-500}\right) m_e$. The decay scheme $\Omega^+ \rightarrow P + \pi^0$ is suggested. On this basis the Q-value is $\left(140^{+40}_{-30}\right)$ MeV and the mass of the hyperon $\left(2\,370^{+80}_{-60}\right) m_e$, the time of flight being 3×10^{-11} sec. D. J. PROWSE

539.18

6496. Possible example of decay of a "meson active triton" at rest. P. CIOK, M. DANYSZ AND J. GIERULA. *Bull. Acad. Polon. Sci. Cl.* 3, 3, *No.* 1, 25–7 (1955).

A black track which ends in the emulsion in a two-prong star is observed to emerge from a star of type $37 + 7p$. Rough estimates of the mass of the particle causing this track from scattering-range measurements on 520μ give $2 \cdot 7 m_p$. Scattering and grain-density measurements on the longest component of the two-prong star indicate a mass of about $400\, m_e$. Assuming this to be a π-meson, the grain-density yields a value for the kinetic energy of 50 ± 15 MeV. Considering the other track as a He^3 nucleus, its kinetic energy is $2 \cdot 6 \pm 0 \cdot 6$ MeV. D. J. PROWSE

539.18

6497. A search for angular correlations in τ-meson decay. M. TEUCHER, W. THIRRING AND H. WINZELER. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 4, 733–4 (*April*, 1955).

The distribution of the angles between the plane of decay of nine τ-mesons and the direction of emission of the τ's from the parent stars is investigated. The distribution appears to be non-isotropic but the number of events is too small to permit a definite conclusion. H. ELLIOT

539.18

6498. Evidence for heavy mesons with the decay processes $K_{\tau 2} \rightarrow \pi + \pi^0$ and $K_{\mu 2} \rightarrow \mu + \nu$ from observations with a multiple cloud chamber. H. S. BRIDGE, H. DESTAEBLER, JR, B. ROSSI AND B. V. SREEKANTAN. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 874–87 (*May*, 1955).

Analysis of the data on *S*-events observed in the M.I.T. multiplate cloud chamber shows that these events represent the decay processes of two kinds of heavy mesons. The decay processes are of the type: $K_{\mu 2} \rightarrow \mu + \nu$ and $K_{\tau 2} \rightarrow \pi + \pi^0$. A.

539.18

6499. Further discussion of the K_μ decay mode. R. ARMENTEROS, B. GREGORY, A. HENDEL, A. LAGARRIGUE, L. LEPRINCE-RINGUET, F. MULLER AND C. PEYROU. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 915–41 (*May*, 1955).

After a description of the methods used in the measurements of momentum and range, the data on 46 *S*-events obtained with a double cloud-chamber experiment are examined. Momentum-range measurements on 22 positive *S*'s give a mass consistent with a single value at $(928 \pm 13)\, m_e$. The analysis of the ranges of the secondaries shows, however, that not all *S*-events can be explained by a single decay mode. A large proportion of the secondaries correspond to a light meson of unique range $(75 \cdot 7 \pm 1 \cdot 7)$ g.cm^{-2} Cu. The comparison of this range with the measured masses of the primary particles proves that these secondaries are μ-mesons. The accompanying neutral secondary is shown at the same time to be a particle of zero mass. The absence of cascade showers associated with *S*-events with long-range secondaries shows that the neutral secondary is a neutrino. The decay mode $K_\mu \rightarrow \mu + \nu$ previously proposed is more firmly established. Two independent mass estimates are obtained for the K_μ-particle. One—from momentum-range measurements—gives directly $(906 \pm 27)\, m_e$. Another—from the mode of decay and the range of the μ-secondary—gives indirectly $(941 \pm 11)\, m_e$. A final best mass of $(935 \pm 15)\, m_e$ is obtained by the combination of the two estimates after taking into account possible additional errors. The K_μ-particle is then shown to be essentially positive and to constitute $(66 \pm 18)\%$ of the *S*'s which passed through the top chamber. No precise information can be obtained as to the mode of decay of *S*-particles which are known not to belong to the K_μ-decay mode. A.

539.18

6500. Angular distribution of pions from θ^0 decay. R. M. STERNHEIMER. Letter in *Phys. Rev.*, **98**, *No.* 1, 205–6 (*April* 1, 1955).

The fractional number of decays of a θ^0 is calculated as a function of the angle between the resulting π^+ and π^- for kinetic energies of the θ^0 of 100, 200, 500, 1 000 MeV. Suitable counter experiments could be used to deduce θ^0 energy from the angular distribution. W. J. SWIATECKI

539.18

6501. Example of the cascade decay of a negative hyperon. W. H. ARNOLD, J. BALLAM, G. K. LINDEBERG AND V. A. J. VAN LINT. Letter in *Phys. Rev.*, **98**, *No.* 3, 838 (*May* 1, 1955).

An event has been observed in a magnetic field cloud-chamber which can be explained most reasonably by the decay scheme $Y^- \rightarrow \Lambda^0 + \pi^- + 63 \pm 9$ MeV. The Λ^0 then decays at a point 1·1 cm from the hyperon decay point in the manner $\Lambda^0 \rightarrow p + \pi^- + 37 \pm 1$ MeV. The Q-value for the cascade agrees well with those found by other workers. A. J. EGGINTON

539.18

6502. Effect of the anomalous nucleon magnetic moment on the π^0 lifetime. S. COHEN. *Phys. Rev.*, **98**, *No.* 3, 749–50 (*May* 1, 1955).

The anomalous magnetic moment of the intermediate nucleons has been included in a treatment of the two-photon decay of the π^0. It is found that this

inclusion leads to a shorter, rather than a longer, lifetime, thereby failing to reduce the discrepancy between the experimental and previous theoretical values. A.

539.18

6503. Mass and decay of charged hyperons. A. BONETTI, R. L. SETTI, B. LOCATELLI AND G. TOMASINI. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 292–6 (1954).

Measurements on seven decaying charged hyperons are reported. Four of these, decaying at rest, were found during a systematic study of all particles coming to rest and decaying to a single charged secondary. The remaining three, which decay in flight, were found whilst scanning for 2-prong stars. The energies of the parent stars vary within wide limits and one of the hyperons originates in a K^--star. From one of the events, giving a stopping proton secondary, a primary mass of $2327 \pm 3\,m_e$ is deduced assuming decay into a proton and a π^0-meson. P. ROTHWELL

539.18

6504. The sign of the K_μ-particle. R. ARMENTEROS, B. GREGORY, A. LAGARRIGUE, L. LEPRINCE-RINGUET, F. MULLER AND C. PEYROU. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 324–6 (1954) In French.

An intensive search has been made for negative K_μ-particles in photographs obtained with the double cloud-chamber arrangement at the Pic du Midi. None were found; the same photographs yielded 19 K_μ^+ decays. One negative particle, showing evidence of γ-ray emission at the stopping point, was found giving a mass of $1250 \pm 90\,m_e$. P. ROTHWELL

539.18 : 778.34

6505. Methods of determining the masses of charged particles detected in nuclear emulsions. A. ORKIN-LECOURTOIS, T. F. HOANG, D. MORELLET AND G. KAYAS. *J. Phys. Radium*, **16**, *No.* 3, 16 S–22 S (*March*, 1955) In French.

Four methods are described and discussed: scattering *v.* range, grain-density *v.* range, photometric-ionization *v.* range and gap-density *v.* range. These methods have been applied where possible to 24 *K*-meson tracks (*K*-Ep 7–30), to 1 K^- track (K^--Ep 1) and to 3 known τ-meson tracks. D. J. PROWSE

539.18

6506. Study of heavy mesons stopped in photographic emulsions. I. Experimental results on the masses of primary mesons. T. F. HOANG, L. JAUNEAU, J. JOUVIN, G. KAYAS, L. LEPRINCE-RINGUET, D. MORELLET, A. ORKIN-LECOURTOIS AND J. TREMBLEY. *Nuovo Cimento Suppl.* (*Ser.* 10) **1**, *No.* 3, 172–85 (1955) In French.

Results are given on the mass estimation of 34 heavy mesons by means of the following methods: (I) Grain-density *v.* range; (II) Gap-density *v.* range; (III) Photometric opacity *v.* range; (IV) Scattering *v.* range. For details of each method see below. The aim is to investigate a way in which the data obtained can be compared and combined. Among the 34 heavy mesons are found: (1) 29 cases having one single charged relativistic secondary; (2) 2 cases of τ; (3) one case interpreted as τ' with $E_\pi = 22{\cdot}3$ MeV; (4) one case showing a low energy μ-secondary followed by a decay electron, $E_\mu = 33{\cdot}3$ MeV; (5) one case of a negative heavy meson giving rise to a nuclear disintegration at the end of its range. The average masses of three τ-mesons [cases (2) and (3)] according to four methods are as follows: Method I: $M = 957 \pm 40\,m_e$; Method II: $M = 942 \pm 80\,m_e$; Method III: $M = 943 \pm 44\,m_e$; Method IV: $M = 1030 \pm 115\,m_e$. The final average of all these is: $955 \pm 28\,m_e$. For heavy mesons with a relativistic secondary [case (1)] the average masses are: Method I: $M = 948 \pm 27\,m_e$; Method II: $M = 942 \pm 28\,m_e$; Method III: $M = 908 \pm 17\,m_e$; Method IV: $M = 952 \pm 49\,m_e$; which lead to the final average: $926 \pm 13\,m_e$. The error is the standard deviation. An additional error of $12\,m_e$ is added in order to take into account possible bias. This leads finally to: $\bar{M} = 926 \pm 25\,m_e$. The average mass of heavy meson with a low-energy secondary [case (4)] is: $1172 \pm 56\,m_e$. The possibility that this particle is significantly heavier than those of the 29 previous cases is discussed. A statistical method is used to test the possible existence of a mixture of particles of two distinct masses. Numerical results are given for the particles of case (1) using the shape of the mass spectrum deduced from the photometric measurements and the average value of the mass 926 ± 25. The existence of a particle of mass around $1030\,m_e$ (or heavier) in large proportion is found to be very unlikely. A.

539.18 : 778.34

6507. Study of heavy mesons stopped in photographic emulsions. II. 1. Method of estimation of mass by grain density–residual range. T. F. HOANG. *Nuovo Cimento Suppl.* (*Ser.* 10) **1**, *No.* 3, 186–99 (1955) In French.

An attempt has been made to improve the mass measurement by grain-counting using large cells, containing about 1000 grains. Different errors are discussed, especially those due to non-uniformity in the sensibility and processing of emulsions. The principle of the method is based on the observed proportionality in a certain region between the energy loss suffered by a charged particle due to ionization in the emulsion and the grain-density; the two constants of the relationship connecting these two quantities have been determined by means of 20 π-mesons. This relation is then used for the mass estimation. To calculate the errors a constant term of 3% is added to the statistical error in order to take into account the non-uniformity of the emulsion. The errors thus calculated agree with the dispersion of the masses of the 20 π-mesons used for calibration. The method has been applied to 19 heavy mesons observed in stripped emulsions having each a range over 8 mm. A.

539.18 : 778.34

6508. Study of heavy mesons stopped in photographic emulsions. II. 2. Method of estimation of masses by gap counting. G. KAYAS. *Nuovo Cimento Suppl.* (*Ser.* 10) **1**, *No.* 3, 200–8 (1955) In French.

Integral gap number counting is discussed and applied to mass estimation of 24 *K*-mesons stopping in a stack of electron sensitive emulsions. A total of 40 protons ending in the emulsions was used for calibration purposes and error estimation. The weighted average of the *K*-meson masses was found to be: $M_K = (942 \pm 28)\,m_e$ with dispersion $130\,m_e$. A.

539.18 : 778.34

6509. Study of heavy mesons stopped in photographic emulsions. II. 3. Method of estimation of mass by photometric density–residual range (photometer with two slits). D. MORELLET. *Nuovo Cimento Suppl.* (*Ser.* 10) **1**, *No.* 3, 209–21 (1955) In French.

A photometer having two slits of different apertures is described. The image of the broader slit (broad slit of aperture $> 2\mu$) remains in a fixed position while the image of the narrow slit describes a periodic and uniform motion about the centre of the broad one, to survey the neighbourhood of the measured track. An optical arrangement allows measurements to be made in standardized conditions There are two ways to estimate ionization: I. by the transversal opacity distribution, given by the narrow slit. II. by measuring the total light transmitted by the broad slit. In this case, the narrow slit is only used for normalization and to eliminate bad background distortions. A.

539.18 : 778.34

6510. Study of heavy mesons stopped in photographic emulsions. II. 4. Method of estimation of mass by multiple scattering–residual range. A. ORKIN-LECOURTOIS. *Nuovo Cimento Suppl.* (*Ser.* 10) **1**, *No.* 3, 222–9 (1955) In French.

In order to estimate the mass of 20 K-mesons observed in a Sardinia stack of emulsions by means of the constant sagitta method, 50 identified protons and π-mesons were measured with cell schemes giving the same signal-to-noise ratio for all masses. A calibration constant ρ_0 and an experimental value of the standard deviation have been thus obtained, the error is then derived from the latter. Corrections are applied. The distortion effects either measured directly or through the sagitta distribution are observed to be negligible, small cell schemes being used. Results concerning τ- and K-mesons are given. A.

539.18

6511. Study of heavy mesons stopped in photographic emulsions. III. Experimental results on heavy meson secondaries. L. JAUNEAU AND J. TREMBLEY. *Nuovo Cimento Suppl.* (*Ser.* 10) **1**, *No.* 3, 230–44 (1955) In French.

An analysis is given of heavy-meson secondaries which have not been observed to come to rest in the emulsion. The ionization–scattering method used in the mass estimates is described. The precision of this method has been verified by measurements on 10μ-mesons and 19π-mesons. Twenty-three heavy-mesons emitting an energetic single charged secondary have been observed. Only 4 secondaries had a sufficiently long path in each plate to allow an estimate of their nature and energy. It is not possible with this method to distinguish between μ- and π-mesons in single cases. Nevertheless, a combination of mass estimates and $p\beta c$ values appear to indicate that the secondaries of K_{13}; K_{17} and K_{22} are μ-mesons with $p\beta c$ compatible with a single value at (209 ± 9) MeV. On the other hand, the secondary of K_{23} would correspond to a π-meson with $p\beta c = (116 \pm 18)$ MeV. A.

539.18

6512. Photoproduction of π^+ mesons from hydrogen near threshold. J. E. LEISS, C. S. ROBINSON AND S. PENNER. Letter in *Phys. Rev.*, **98**, *No.* 1, 201–2 (*April* 1, 1955).

Total cross-section for π^+-mesons was determined in the range 140–200 MeV by counting positrons emitted in the decay of the μ^+ stopped in a carbon jacket surrounding a liquid H target. The magnitudes of the coupling constants and the difference of the S-wave phase shifts are deduced. W. J. SWIATECKI

539.18

6513. Low-energy photoproduction of π^0 mesons from hydrogen: total cross section. F. E. MILLS AND L. J. KOESTER, JR. Letter in *Phys. Rev.*, **98**, *No.* 1, 210–11 (*April* 1, 1955).

These were deduced from measurements at 85° to an X-ray beam (120–250 MeV) passing through a liquid H target. The bearing of the results on an S and P phase-shift analysis is discussed. (See following abstract.) W. J. SWIATECKI

539.18

6514. Low-energy photoproduction of π^0 mesons in hydrogen: differential cross sections at 135°. L. J. KOESTER, JR. Letter in *Phys. Rev.*, **98**, *No.* 1, 211–12 (*April* 1, 1955).

These were measured for incident proton energies of 180–215 MeV by observation (in emulsions) of the recoil protons. The results are fitted using S and P phases, including S–P interference. (Compare preceding abstract.) W. J. SWIATECKI

539.18

6515. Pion production by electrons. W. K. H. PANOFSKY, C. M. NEWTON AND G. B. YODH. *Phys. Rev.*, **98**, *No.* 3, 751–5 (*May* 1, 1955).

The production of π^+-mesons directly by 500 MeV electrons has been studied in lithium. The measurements consist of a precise measurement of the ratio of electron-produced to bremsstrahlung-produced pion yields. Results expressed as "equivalent radiation length" X_e for electron production are $X_e = 0{\cdot}0233 \pm 0{\cdot}0012$ for pions of 55 MeV, and $0{\cdot}0185 \pm 0{\cdot}0014$ for pions of 150 MeV at 75° to the incident electron beam. The results are fully compatible with purely electromagnetic interaction of the electrons. Within the limitations of the experimental data obtained to date, and of the available theoretical studies, the results are compatible with magnetic-dipole absorption as the predominant process in photopion production under the conditions indicated. A.

539.18

6516. Polarization effects in the reaction $p + p \rightarrow \pi^+ + d$. L. WOLFENSTEIN. *Phys. Rev.*, **98**, *No.* 3, 766–9 (*May* 1, 1955).

The reaction $p + p \rightarrow \pi^+ + d$ is represented by matrix operating on the initial spin state on the assumption that the pion leaves only in s- and p-waves. This matrix is determined by five real parameters which may be experimentally determined by measurements of the different types of polarization of the outgoing deuterons and also of the asymmetry produced by incident polarized protons. Some effects of d-waves on the latter are considered. A.

539.18

6517. On heavy unstable particles produced in high energy nuclear disintegrations. C. DAHANAYAKE, P. E. FRANCOIS, Y. FUJIMOTO, P. IREDALE, C. J. WADDINGTON AND M. YASIN. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 5, 888–903 (*May*, 1955).

The results of a systematic investigation into the production of heavy unstable particles in energetic nuclear disintegrations is reported. Mass measurements by the grain density-range method have been made in order to detect *K*-mesons independently of any secondary effects. Measurements were made on tracks which satisfied certain geometrical criteria and which originated in disintegrations of energy greater than ~2 GeV. The velocity range studied for *K*-mesons was from 0·25 to 0·56 *c*. Ten *K*-mesons and two hyperons were found. The two hyperons and one of the *K*-mesons decayed in flight. All the particles decayed into single charged secondaries. Both hyperons were emitted from disintegrations which also produced *K*-mesons. These associated pairs have been reported previously. The results are consistent with the view that hyperons and heavy mesons are mainly produced in association, and that, in the energy range considered, *K*-mesons show a large charge disparity. Two additional hyperons were found one of which appears to be an example of the decay scheme $Y^{\pm} \rightarrow \Lambda^0 + \pi^{\pm} + \sim 60$ MeV. A value for the lifetime of the hyperons is estimated from six suitable examples found in this laboratory. Mass measurements have been made on the tracks of 17 *K*-mesons. The mean value obtained is $985 \pm 16 m_e$. A.

539.18

6518. The production of hyperons and heavy mesons. G. D. JAMES AND R. A. SALMERON. *Phil. Mag.*, **46**, 571–86 (*June*, 1955).

A full dynamical analysis of the reaction $\pi + N \rightarrow Y + K$ . . (1) is given and it is shown that some of the results apply to the production of hyperons in any collision with a free nucleon at rest. In particular, difficulty is found in accounting for the low-energy hyperons that are frequently observed in both cloud chambers and photographic emulsion. Their existence necessitates a mechanism by which hyperons can lose most of their energy. It is suggested that this process is scattering by nucleons. Nineteen cloud chamber photographs showing two *V*-events associated with the same nuclear interaction are discussed. In no case do the *V*-events represent the decays of the two secondaries of reaction (1). The observed frequency of associated *V*-events provides no evidence for or against the hypothesis that heavy unstable particles are always produced in reaction (1) or in similar "double production" reactions. Because the secondary particles from these reactions are scattered in heavy nuclei it is concluded that the reactions can best be studied in light materials. A.

539.18 : 530.145

On multiple production of mesons by high energy nucleon collisions. *See Abstr.* 5894

539.18

6519. A calibration measurement of multiple scattering of slow μ-mesons by the constant sagitta method. S. KANEKO. *J. Phys. Soc. Japan*, **16**, *No.* 5, 325–33 (*May*, 1955).

Multiple scattering observations have been carried out on 103 slow cosmic-ray μ-mesons coming to rest in G5 emulsions. The emulsions were coated, exposed and processed at a depth of about 17 m.w.e. underground. It is shown that the constant sagitta scheme recommended by the Göttingen group gives satisfactorily constant mean sagittae with increasing residual range at least in the region of velocity $0 \lesssim \beta \lesssim 0{\cdot}46$. Observations of 81 μ-mesons are also described which were done by the scheme based upon the Williams theory of scattering and upon the range-energy relation given by Bradner *et al.* The error introduced by the use of schemes other than that of Göttingen is discussed. The results are compared with Glasser's calibration experiment on 101 artificially produced slow protons. A.

539.18

6520. Scattering of mesons by light nuclei. L. S. KISSLINGER. *Phys. Rev.*, **98**, *No.* 3, 761–5 (*May* 1, 1955).

An improved optical model is used to study the scattering of mesons by light nuclei, C^{12} in particular. It is found that the differential cross-section will fit reasonably well if a nucleus is used which has a diffuse edge; the Gaussian shape seems to work well for C^{12}. A.

539.18 : 539.172.4

6521. Scattering of high-energy neutrons and Johnson–Teller type nuclei. Y. NAKANO. Letter in *Phys. Rev.*, **98**, *No.* 3, 842–3 (*May* 1, 1955).

The optical method has been extended to the Johnson–Teller type non-uniform nuclear model [Abstr. 4829 (1954)], to derive total, absorption and diffraction cross-sections. Evidence for the J–T model is obtained from an analysis of the total cross-section measurements, particularly in the 275–410 MeV region. P. T. MATTHEWS

539.18

6522. Results on neutral *V*-particles. M. CECCARELLI, M. GRILLI AND B. VITALE. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 305–6 (1954).

Whilst following back about 300 π^+-mesons from their stopping points, four *V*-events have been found. In each case the π-meson is negative and three of the events can be interpreted as Λ^0-decays; the fourth, however, gives a *Q*-value of about 15 MeV.

P. ROTHWELL

539.18

6523. An unstable heavy fragment. K. GOTTSTEIN. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 309 (1954).

Describes the disintegration of a heavy fragment emitted from a star of type $27 + 4p$. The fragment is probably Be^9 or Be^{10} and the energy release in >104 MeV. P. ROTHWELL

539.18

6524. Two unstable fragments. M. GRILLI, B. SECHI AND G. T. ZORN. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 310 (1954).

Describes observations on two unstable fragments, probably Be^9 and Li^7 respectively, emitted from energetic nuclear interactions. Both of these events

can be explained by the non-mesonic decay of a bound Λ^0-particle. P. ROTHWELL

539.18

6525. Results on charged *V*-particles. R. ARMENTEROS, B. GREGORY, A. LAGARRIGUE, L. LEPRINCE-RINGUET, F. MULLER AND C. PEYROU. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 327–32 (1954) In French.

An analysis is made of all the available data on charged *V*-particles. From an examination of their sign distribution (139 +, 94 −), and the distribution in p^* of the secondaries for 27 of these events, it is concluded that the majority of the charged *V*-particles cannot be either K_μ or τ. Both μ- and π-mesons have been indentified among the secondary particles and it is tentatively suggested those *V*-particles which are neither K_μ nor τ may be $K^\pm$ (mass $> 1000\,m_e$) and Y^--particles. Preliminary lifetime estimates give values of $2{\cdot}8\times10^{-8}$ sec and ~2, 4×10^{-9} sec for K_μ^+ and $K^\pm$ respectively. The ratio $K_\mu^+/K^\pm$ at production is estimated as $\sim1{\cdot}7$. One cascade decay of a hyperon was observed and the charged secondary was identified as a π-meson by its subsequent interaction. P. ROTHWELL

539.181 : 537.228.5

6526. Focusing polar molecules. H. G. BENNEWITZ, W. PAUL AND C. SCHLIER. *Z. Phys.*, **141**, *No.* 1–2, 6–15 (1955) In German.

A beam of molecules with electric dipole moments is directed along the axis of an electric field whose transverse gradient is such that the restoring force on the molecules is proportional to their distance from the beam axis when the exact Stark effect is considered. The molecules then execute cosine curves and are refocused on the axis every half wavelength. This condition can be reached with low J and M values, and the nature of the four-pole field, the effect of oven aperture and other variables are discussed. The construction of such a focusing device is described; it incorporates mechanical stops for non-focused molecules, a mechanical velocity selector, and a Langmuir–Taylor detector. Detector current–voltage curves up to 8 kV indicate for KBr successive focusing of $(J, M) = (1, 0)$, $(2, 0)$, $(3, 0)$ and $(2, 1)$ states and for KF the $(1, 0)$ and $(2, 0)$ states with signals about 60 times the null signal. D. H. WHIFFEN

539.185

6527. The absorption of neutrons by a small, strongly absorbing rod. R. J. ROYSTON. *Atomic Energy Res. Establ.* [*Harwell*] *Mem.*, *T/M* 117, 5 *pp.* (1954).

The flux of neutrons inside a small rod of strongly absorbing, non-scattering material is calculated on the assumption that the incident flux of neutrons is isotropic. The number of neutrons absorbed by such a rod placed in an isotropic flux of neutrons is then deduced. A.

539.185

6528. General perturbation theory in neutronics. E. D. PENDLEBURY. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 6, 474–81 (*June*, 1955).

A general approach to perturbation theory in neutronics is given, and particular cases of one and two energy groups are considered. A method is also suggested for the treatment of large perturbations. A.

539.185 : 537.534.74

Polarization of fast protons and neutrons. *See Abstr.* 6237

539.185

6529. A neutron generator using $T(d, n)$ reaction. A. N. BANERJEE. *Sci. and Culture*, **20**, *No.* 9, 454–5 (*March*, 1955).

Describes the operation and approximate calibration of a 52 kV D–T neutron source. J. M. CASSELS

539.185

6530. Neutron spectrum and absolute yield of a plutonium–beryllium source. L. STEWART. *Phys. Rev.*, **98**, *No.* 3, 740–4 (*May* 1, 1955).

A Pu–Be neutron source has the advantages of high neutron yield, low γ-ray intensity and very long half-life. The neutron spectrum from such a source, composed of 13 g of plutonium and 7 g of beryllium as $PuBe_{13}$ (density $3{\cdot}7\,g/cm^3$), was measured by means of proton recoils in nuclear research emulsions. The data obtained from 2057 observations indicate the neutrons have a maximum energy of approximately 10·5 MeV with broad intensity maxima at 4·0, 7·2 and 9·7 MeV. The observed spectrum shows marked similarities with published data on neutrons from Po–Be and Ra–Be sources. A comparison is made between the present data and previously reported energy levels in the residual carbon nucleus. The absolute yield of neutrons above 0·5 MeV energy is $1{\cdot}2\times10^6$ neutron/sec. A.

539.185

6531. High-current Cockcroft–Walton accelerator for neutron production. R. A. PECK, JR AND H. P. EUBANK. *Rev. sci. Instrum.*, **26**, *No.* 5, 444–8 (*May*, 1955).

The 200 keV deuteron accelerator described utilizes a water-cooled T–Zr film as a source of 14 MeV neutrons. High voltage is provided by a Cockcroft–Walton generator of six oil-filled stages, operated at 32 kc/s. An r.f. ion source provides up to 15 mA (90% deuterons), at least 10 mA of which can be focused on the target. A system of forced water cooling allows at least 5 mA (at 120 keV) to be used in bombarding the target foil without reaching a surface temperature of 100°C. Observed neutron yield is approximately 2×10^9 neutrons/sec.mA from a target containing roughly one tritium atom per four of zirconium. A.

539.185

6532. The scattering of slow neutrons by *ortho*- and *para*-hydrogen. G. L. SQUIRES AND A. T. STEWART. *Proc. Roy. Soc. A*, **230**, 19–32 (*June* 7, 1955).

The neutron velocity selector of the Cavendish Laboratory has been used to measure the scattering cross-sections of *ortho*- and *para*-hydrogen for slow neutrons. The triplet and singlet scattering amplitudes of the neutron–proton interaction may be deduced from these cross-sections. The values obtained are $a_t = (0{\cdot}537 \pm 0{\cdot}004)\times10^{-12}$ cm, $a_s = -(2{\cdot}373 \pm 0{\cdot}007)\times10^{-12}$ cm, where a_t and a_s are the triplet and singlet scattering amplitudes, respectively. The values of the coherent scattering amplitude $f = 2(\frac{3}{4}a + \frac{1}{4}a_s)$, and of the free proton cross-section $\sigma_f = 4\pi(\frac{3}{4}a_t^2 + \frac{1}{4}a_s^2)$ given by the above values of a_t and a_s, are $f = -(0{\cdot}380 \pm 0{\cdot}005)\times10^{-12}$ cm, $\sigma_f = (20{\cdot}41 \pm 0{\cdot}14)\times10^{-24}$ cm^2. A.

539.185

6533. The inelastic scattering of neutrons by magnetic spin waves. R. J. ELLIOTT AND R. D. LOWDE. *Proc. Roy. Soc. A*, **230**, 46–73 (*June* 7, 1955).

The inelastic scattering of neutrons by ferromagnetic and antiferromagnetic crystals is considered on spin-wave theory, using the formalism of Holstein and Primakoff. The influence of dipole-dipole interaction and of an applied magnetic field is examined in detail for ferromagnetic crystals. Scattered intensity distributions and total cross-sections are derived in terms of the angular setting of the crystal; they are valid at temperatures low compared with the relevant critical temperatures. The spin-wave interaction leads to magnetic diffuse reflection of neutrons from the crystal planes, closely analogous to the phonon diffuse reflection of neutrons and X-rays. These reflections become intense near the positions for magnetic Bragg scattering: with antiferromagnetic crystals there is an additional set of feeble diffuse reflections near the directions of nuclear Bragg scattering. The spin-wave diffuse reflections are always superposed on phonon reflections. However, in antiferromagnetics the nuclear and magnetic parts of phonon scattering are separated, so that the principal spin-wave reflections fall on the magnetic part only. Anisotropy forces affect the intensity only for settings very near the Bragg angle. The phenomenon is capable of giving very direct information on the low-lying energy states of magnetic crystals. Cross-sections, however, are of the order of millibarns and detailed consideration is given to the problem of their experimental isolation. A.

539.185

6534. Mechanical filter for the spectrometry of cold neutrons. M. GALULA AND F. NETTER. Letter in *J. Phys. Radium*, **16**, *No.* 3, 233–4 (*March*, 1955) In French.

The arrangement of rotating cadmium sectors described transmits only neutrons of wavelength greater than some minimum value. J. J. WILKINS

539.185.08

6535. Effect of orientation on the activity of neutron probes. M. DE ARÁNZAZU VIGÓN. *An. Real Soc. Españ. Fis. Quím.*, **50**(A), *No.* 11–12, 215–20 (*Nov.–Dec.*, 1954) In Spanish.

The formulae relating activity and position of a neutron-irradiated indium foil, have been verified experimentally. Measurements with both thin and thick foils for epithermal neutrons and with thick foils for thermal neutrons have been carried out. The experimental results agree qualitatively with the theoretical predictions. A.

STRUCTURE OF SOLIDS 539.2

539.217

6536. Radiation damage and diffusion processes in the noble metals. A. SEEGER. Note in *Z. Naturforsch.*, **10a**, *No.* 3, 251–3 (1955) In German.

It is suggested that the recovery of the resistivity of noble metals after damage by irradiation, cold work, or quenching, can be attributed to five main processes, not all of which occur in any one condition. At 35–45°K a re-ordering of melted zones (in irradiated specimens) occurs; at 130–220°K, diffusion of groups of vacancies; at 220–270°K, movement of single interstitial atoms; at 370–470°K, movement of single vacancies; and above 500°K, self-diffusion processes are important. The activation energies associated with these five stages are given as 0·1, 0·2–0·5, 0·7, 1·19 and 2·09 eV respectively. W. M. LOMER

539.217

6537. Anisotropic diffusion lengths in diffusion theory. B. I. SPINRAD. *J. appl. Phys.*, **26**, *No.* 5, 548–50 (*May*, 1955).

A set of formulae defining diffusion lengths in heterogeneous assemblies is presented. Even in the homogeneous limit, these formulae lead to anisotropic diffusion lengths for systems such as rod or slab assemblies which are microscopically anisotropic. A.

539.217

6538. Diffusion rates in solids. R. PERRIN. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 13, 1388–90 (*March* 28, 1955) In French.

It is usually assumed that the diffusion flow rates in solids are given by Fick's laws in all circumstances. It is pointed out that there is no thermodynamic justification for this assumption; if chemical changes arise as a result of the diffusion there may be very large free energy changes compared with those involved in homogenization, and this difference could be reflected in the rates. Two experiments in which this may be the case are cited, one in which a very rapid precipitation of CrC in stainless steel cannot be reversed in comparable times, and the other the rapid diffusion of Zn in brass which is slowly oxidized to precipitate ZnO. W. M. LOMER

539.217

6539. Note on self-diffusion of nickel. H. BURGESS AND R. SMOLUCHOWSKI. Letter in *J. appl. Phys.*, **26**, *No.* 4, 491–2 (*April*, 1955).

A brief report of preliminary measurements using Ni^{63} as tracer. D was measured between 250 and 1250°C; at 1000°C the value is $1{\cdot}5\times10^{-12}$ cm²/sec and the activation energy is between 61 and 65 kcal/mole. Below 650°C the activation energy is between 10 and 15 kcal/mole; this low value is attributed to grain boundary diffusion. W. M. LOMER

539.219

6540. Kirkendall effect in precipitation processes from supersaturated mixed crystals. B. ILSCHNER. Note in *Naturwissenschaften*, **42**, *No.* 5, 123–4 (1955) In German.

Precipitation from solid solution usually involves diffusion of two kinds of atoms in opposite directions. If there is a Kirkendall effect, this produces a volume change, and consequently elastic stresses which may control velocity and form of growth of the precipitates as well as the hardness of the matrix. W. M. LOMER

539.219

6541. Deviations from Vegard's law. J. FRIEDEL. *Phil. Mag.*, **46**, 514–16 (*May*, 1955).

A modification to the simple treatment of Vegard's law takes account of the different compressibilities of

the component atoms, treating the solute atoms as spheres with the bulk compressibility of the pure metal. The final expression correlates many of the experimental deviations. There are many other complicating factors, especially between elements from different periods, which cannot be included in this model. W. M. LOMER

539.219

6542. An X-ray study of the system uranium monocarbide–uranium dicarbide–beryllium carbide. M. D. BURDICK, H. S. PARKER, R. S. ROTH AND E. L. MCGANDY. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 4, 217–29 (*April*, 1955).

Mixed carbide preparations within the system uranium monocarbide–uranium dicarbide–beryllium carbide were investigated after heating and quenching. X-ray diffraction methods were used to identify the phases found and to determine the degree of interaction. Carbide alloys were studied after treatments at 1 700 and 1 900°C, and a constitutional diagram for the 1 700°C level is presented. No ternary compounds were identified within the system. The limit of solubility of beryllium carbide in uranium monocarbide at 1 700 and 1 900°C was found to be 20 mole% and 40 mole%, respectively. Lattice parameters based on X-ray patterns in the back-reflection region failed to indicate any other interactions, but evidence is presented to indicate some solid solution among the uranium carbides without lattice parameter change. The room-temperature stability of uranium sesquicarbide (U_2C_3), which has been reported by other investigators, was verified. X-ray diffraction data were obtained for this cubic compound, using CuK_α radiation. A.

539.219 : 537.226.2

6543. Solid-state reactions and dielectric properties in the systems magnesia–zirconia–titania and lime–zirconia–titania. L. W. COUGHANOUR, R. S. ROTH, S. MARZULLO AND F. E. SENNETT. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 4, 191–9 (*April*, 1955).

The compatibility relations were determined for each system, and an estimate of the extent of the solid-solution areas was obtained. One ternary compound having the formula $CaO.ZrO_2.2TiO_2$ was discovered. An X-ray diffraction powder pattern of this compound is included. Ceramic dielectric-test pieces were prepared from compositions within these systems. Data are given for the values of K and Q at 50 kc/s, and at 1 and 20 Mc/s. The variations of these values with changes in temperature were observed at a frequency of 1 Mc/s. A.

539.219 : 537.311.31

6544. Theoretical study of residual resistance of binary alloys containing foreign atoms in small concentration. H. FUJIWARA. *J. Phys. Soc. Japan.*, **16**, *No.* 5, 339–46 (*May*, 1955).

The increase of electrical resistance due to the substitutional impurities of di- or trivalent metal for monovalent metal in dilute solid solution is calculated. In the present paper, two steps are taken as follows: First, a modified screened Coulomb field is exactly obtained from the Thomas–Fermi equation by numerical integration, and second, for the calculation of the cross-section, the method of partial wave is used, instead of the Born approximation. The agreement of theoretical results with experiment has been greatly improved by this method in comparison with the results obtained by the use of the Born approximation. A.

539.234 : 537.226.2

6545. Formation of thin films of $BaTiO_3$ by evaporation. C. FELDMAN. *Rev. sci. Instrum.*, **26**, *No.* 5, 463–6 (*May*, 1955).

Ferroelectric films of $BaTiO_3$ approximately 1 to 2μ thick have been formed on platinum substrates by evaporation in a vacuum and a subsequent heat treatment in air. The structure of the crystallites which make up the films is mainly perovskite with the hexagonal phase as a minor constituent. Dielectric measurements show that the Curie temperature is about 120°C. The sharpness of the Curie transition depends to a large extent on the size of the $BaTiO_3$ crystallites. The structure of the film seems to influence the dielectric constant and the saturation and remanent polarization of the film. A.

539.26

6546. Small angle scattering of X-rays by cold-worked metal. J. BLIN. *Defects in crystalline solids* [*Bristol*] 420–2. See Abstr. 5707 (1955).

Measurements on small angle ($<3°$) scattering from cold rolled and from extended foils of pure Cu, Ni, Al and Zn are described. Rolling produces smaller effects than extension. The magnitude of the effects cannot be explained by dislocation scattering, and it is deduced that groups of vacancies are responsible. The groups must be either elongated or disk-shaped, and correspond to volume changes of about 0·03% for reduction in area of 10%. The energy stored as surface energy agrees roughly with measured values. W. M. LOMER

539.26

6547. Small particle X-ray scattering by fibers. Size and shape of microcrystallites. A. N. J. HEYN. *J. appl. Phys.*, **26**, *No.* 5, 519–26 (*May*, 1955).

A theoretical and experimental analysis is given. The scattering by different fibres of high orientation is compared with the theoretical scattering curves derived for independent scattering by an assemblage of parallel cylinders. Under certain conditions of swelling, excellent agreement is obtained between experimental and theoretical curves. From this agreement it is concluded that under these conditions independent particle scattering is realized and that interparticle interference and multiple scattering do not play a part. Under all other conditions (dry fibre and other conditions of swelling) interparticle interference plays an important rôle in the scattering by these "densely packed" materials as can be concluded from the different distributions of intensity. The swelling method offers a means for separating independent and non-independent scattering. An analysis of the influence of various conditions of swelling is made, and the correct experimental conditions for obtaining independent scattering are derived from the results. From the scattering under such conditions, the particle size in different fibres is determined on the basis of the theoretical formulae for independent scattering. A.

539.26 : 539.211

6548. X-ray microbeam studies of brittle fractures of metals. L.-C. CHANG. *J. Mech. Phys. Solids*, **3**, *No.* 3, 212–17 (*April*, 1955).

X-ray microbeam studies of the fracture surfaces of polycrystalline iron and zinc reveal that the plastic strain associated with brittle fracture of both metals can be resolved into two parts: the pre-fracture strain and the fracture strain. Brittle fracture is therefore preceded by plastic strain. The energy associated with the fracture strain component is found to be approximately two orders of magnitude larger than the surface energy of the metal and can thus be regarded as the determining energy term for the propagation of a crack. The experimental results support the dislocation mechanism of crack nucleation in crystalline solids recently advanced by several investigators. A.

ELASTICITY . STRENGTH . RHEOLOGY
539.3/.8

539.32

6549. Temperature variation of the elastic constants of cubic elements. I. Copper. W. C. OVERTON, JR AND J. GAFFNEY. *Phys. Rev.*, **98**, *No.* 4, 969–77 (*May* 15, 1955).

The ultrasonic pulse technique has been used in conjunction with a specially devised cryogenic technique to measure the velocities of 10 Mc/s acoustic waves in copper single crystals in the range from 4·2 to 300°K. The values and the temperature variations of the elastic constants have been determined. The room temperature elastic constants were found to agree well with those of other experimental works. Fuchs's theoretical c_{44} at 0°K is 10% larger than the observed value but his theoretical c_{11}, c_{12}, K and $(c_{11}-c_{12})$ agree well with the observations. The isotropy $(c_{11}-c_{12})/2c_{44}$, was observed to remain practically constant from 4·2 to 180°K, then to diminish gradually at higher temperatures. Some general features of the temperature variations of elastic constants are discussed. A.

539.32 : 535.43

6550. Elastic constants of crystals from light scattering measurements. R. S. KRISHNAN. *Proc. Indian Acad. Sci. A*, **41**, *No.* 3, 91–7 (*March*, 1955).

The frequency shift of light scattered thermally (Brillouin scattering) is measured for four cubic and four birefringent crystals using u.v. light (2536·5 Å) and a 3 m quartz spectrograph. The elastic constants are calculated from the results and agree satisfactorily with the accepted values. J. E. CAFFYN

539.32 : 532.137

6551. Apparatus for low-frequency dynamic measurement on polymeric systems. T. E. MORRISSON, L. J. ZAPAS AND T. W. DEWITT. *Rev. sci. Instrum.*, **26**, *No.* 4, 357–60 (*April*, 1955).

An apparatus is described for the measurement of the low-frequency (0·0003 to 2 c/s) dynamic properties of solid and liquid polymers. It is basically a torsion pendulum driven in forced vibration by a low-frequency sinusoidal current. The current generator, which is a mechanically-driven potentiometer arrangement, is also briefly described. The treatment of data, calibration and areas of usefulness of the instrument are discussed, and an example of the results of its application to a concentrated polymer solution is given. A.

539.32 : 539.374

6552. Research on the solid state at high temperatures by means of ultrasonics. P. G. BORDONI. *Ricerca sci.*, **25**, *No.* 4, 847–59 (*April*, 1955) In Italian.

Part of a systematic investigation of the elastic and anelastic behaviour of some metals (Sn, Pb, Zn, Bi Cd, Mg, Al, Cu) near their melting point. The measurements which have already been made by means of ultrasonic waves, show that both the traction and torsion moduli tend to a value different from zero when temperature increases. Their changes follow a general law which can be derived from the statistical theory of solid state. The dissipation of elastic energy, when it is not affected by any relaxation phenomena, increases with temperature, and a close connection has been found between this increase and creep. A.

539.373 : 548.7

6553. The distribution of dislocations in linear arrays. A. K. HEAD AND N. LOUAT. *Austral. J. Phys.*, **8**, *No.* 1, 1–7 (*March*, 1955).

An approximate method is given for finding the equilibrium distribution of arrays of dislocations. The analysis is based on the assumption that an array of discrete dislocations may be replaced by a continuous distribution of smeared dislocation. The solutions of a number of problems of physical interest are investigated, including some in which dislocations of opposite sign are involved. See also Abstr. 5827 (1952). A.

539.389.3

6554. Stress relaxation of wool fibres in water at strains of 5–20 per cent. B. J. RIGBY. *Austral. J. Phys.*, **8**, *No.* 1, 176–83 (*March*, 1955).

A study has been made of the stress relaxation at fixed longitudinal strains of wool fibres immersed in water, in the post-yield region of their load-strain curves. The fibres were extended at controlled rates up to predetermined strains, particular attention being paid to the first few minutes of the subsequent stress relaxation. It was found that the relaxation curves so obtained could be represented by a sum of one, two or three negative exponentials, which could, in general, be simplified into two main processes, (*a*) a relatively fast relaxation of stress occurring in about the first 60 sec and (*b*) a much slower relaxation. The activation energy of the fast process was found to be approximately 5 kcal/mol. Attempts to calculate activation energies for the slow process showed that the term corresponding to the energy was temperature dependent. Over the range 10–50°c, the values of this term were found to increase from about 22 to 27 kcal/mol. The fast and slow processes are respectively ascribed to the breakdown of weaker and stronger types of cross-linking bonds in the keratin. A.

539.42 : 666

6555. On the resistance to rupture of glass at low pressure. N. TERAO. Note in *J. Phys. Soc. Japan*, **9**, *No.* 5, 879–80 (*Sept.–Oct.*, 1954) In French.

In previous work [e.g. Abstr. 8000 (1953)] the author has expressed the probability of fracture under a load f as $a \exp[-(E_0 - \beta f)/kT]$ where a, E_0 and β are constants. The present note claims to show by experiment that both β and E_0 can be increased by lowering the pressure. R. O. DAVIES

539.43

6556. A general creep and recovery property of metals. A. J. KENNEDY. *Nature* [*London*] **175**, 674–6 (*April* 16, 1955).

Intermittent creep tests have been carried out on a number of metals, over ranges of stress and temperature. By interpreting the results according to an empirical formula previously proposed [Abstr. 7615 (1952)] it is shown that all the metals exhibit a singular generality in their behaviour. The results demonstrate that if the time under stress and the subsequent time of off-stress are fixed then the subsequent creep on restressing is also fixed and is a function only of the exponent of time in the standard creep equation. As the value of this exponent is usually $\sim\frac{1}{3}$, the behaviour is very general. If the temperature-dependent recovery process is expressed by a formula similar to that for creep involving "temperature-compensated time," the results observed would follow if the activation energies for creep and recovery were similar. Some consequences are noted. A. J. KENNEDY

539.43

6557. The theory of fatigue fracture of metals. T. YOKOBORI. *J. Phys. Soc. Japan*, **10**, *No.* 5, 368–74 (*May*, 1955).

After a limit of strain hardening is paired, a fatigue crack is assumed to form as a result of large tensile stress by a piled-up group of dislocations plus an externally applied tensile stress component, with the aid of another stress concentration factor associated with the obstacle or inclusion itself. Nucleation theory was applied to the initiation of the crack. The theoretical S–N curve is in quantitative agreement with the data. The scatter of the number of cycles for fracture, which is an inherent characteristic of fatigue fracture, is, mostly if not wholly, explained as a stochastic phenomenon associated with nucleation process of the fatigue crack. The theoretical temperature–dependence of fatigue strength is in fairly good agreement with the data in the literature. A.

539.501

6558. Dynamic behaviour of linear rheological bodies under periodic stresses. S. IRMAY. *Quart. J. Mech. appl. Math.*, **7**, *No.* 4, 399–409 (*Dec.*, 1954).

The simpler linear rheological bodies—such as the elastic and Kelvin's solids, Maxwell's and Newton's viscous fluids—obey a generalized linear differential equation with constant coefficients between the strain and stress deviators and their time rates. The various coefficients are correlated to the asymptotic rigidity or static elastic modulus G, elastic firmness or dynamic modulus H, solid viscosity μ, times of relaxation R and of lagging or retardation L, and the endosity η. Expressing the time and stress in non-dimensional forms, a universal equation is obtained, dependent on a single non-dimensional parameter, the "time factor" $\tau = R/L = G/H$. This defines a principle of similitude for all bodies of identical τ. The mechanical and thermodynamic study of periodic, impulsive and transient stresses leads towards a new classification of the linear bodies, based on the value of τ: (*a*) The *exothermal or dissipative bodies* ($\tau < 1$) are less rigid than firm, less strained than elastic solids, dissipate energy in a cycle. They warm up adiabatically. Here belong also Maxwell's elastico-viscous fluids and Kelvin's firmo-viscous solids ($\tau = 0$). (*b*) The *endous solids* ($\tau > 1$) are more rigid than firm, more strained than elastic solids, may show a "negative" dissipation in a cycle, which is compensated by internal structural changes. This is not in contradiction with the second law of thermodynamics and may explain the fatigue of such solids. (*c*) The *homothermal solids* ($\tau = 1$) are as rigid as firm, show no apparent dissipation in a cycle. A particular case is that of elastic solids. The stress–strain diagram under periodic stresses tends towards an ellipse, which shows accommodation of the body. The smaller axis passes through a maximum for a critical frequency, and the body has two independent elastic moduli—a static and a dynamic one. These facts were experimentally confirmed for certain plastics. A.

539.53

6559. On cold hardening. U. DEHLINGER. *Defects in crystalline solids* [*Bristol*] 423. See Abstr. 5707 (1955).

Inclusion of a term expressing the entropy of the random distribution of clusters of atoms in a solid solution allows explanation of pre-precipitation hardening. The form and existence of pre-precipitation zones in Al 38 weight% Ag and in Al–Cu can be explained, as can the absence of such zones in Au–Ni. W. M. LOMER

539.61

6560. On the role of electrical phenomena in the adhesion of films. B. V. DERYAGIN, N. A. KROTOVA AND V. V. KARASEV. Letter in *Zh. tekh. Fiz.*, **24**, *No.* 7, 1354–7 (1954) In Russian.

A criticism of a paper by Skinner, Savage and Rutzler [Abstr. 4433 (1953)] on electrical phenomena in adhesion. The particular system used (metal–polymer–metal) is claimed to be too complex. It is pointed out that dissipation of energy, as a discharge through the air gap formed during the breaking away of the polymer film from the metal, was not taken into account in the development of the electrical theory of adhesion. The authors also failed to appreciate the fact that when the film is peeled off gradually, in contrast to simultaneous removal over the whole area, the electrical component of adhesion can be greater than the molecular component by several orders of magnitude. It is claimed that Deryagin and Krotova [*Dokl. Akad. Nauk SSSR*, **61**, 849 (1948)], and not Skinner, Savage and Rutzler, were the first to put forward an electrical theory of adhesion. The letter concludes with a description of

an apparatus now used by Deryagin and co-workers to study the emission current associated with the peeling of polymer films from various backings in vacuum. J. A. SPINK

539.67

6561. Internal friction of an alloy of 16 per cent aluminium in iron. C. WERT. Letter in *J. appl. Phys.*, **26**, *No.* 5, 640–1 (*May*, 1955).

Wire specimens of square section, machined from hot-rolled sheet, were tested (after a high-temperature vacuum anneal) for damping by a torsion pendulum method, over the temperature range 950–0°C. A high maximum in the damping near 750°C and a lower peak around 475°C are attributable to relaxation at grain boundaries and stress-induced ordering, respectively, and increased damping below 300°C is probably magnetic in origin. The measurements do not indicate the presence of interstitial impurities. J. G. OLDROYD

539.8

6562. Methods and results of research on the volume elasticity of matter. M. KORNFEL'D. *Uspekhi Fiz. Nauk*, **54**, *No.* 2, 315–42 (1954) In Russian.

A very useful summary of modern methods is given in the first half of the paper. The second half reviews results. Two-thirds of the 24 refs. are to work of Bridgman. C. R. S. MANDERS

539.89 : 523.4

The gravitational compression of an elastic sphere. *See Abstr.* 5826

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.123

6563. Treatment of isotopic exchange reactions having complex mechanisms. R. A. MARCUS. *J. chem. Phys.*, **23**, *No.* 6, 1107–12 (*June*, 1955).

The reaction rate v. time data of isotopic exchange reactions have been shown by previous work to obey a first-order rate law, neglecting differences in isotopic reactivity. A simple method, of use in reactions having complex mechanisms, is developed for relating this first-order rate constant to the rate constants of elementary steps in the process. The method involves examining the progress of specified atoms through the reaction sequence, and is applicable regardless of the number of exchange positions of the reactants, or of whether or not one isotope is present in tracer amounts. These results are used to reinterpret some data on the deuteration of diborane. A.

541.124

6564. Effect of ions on gas reactions. V. L. TIMAN. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 5(11) 653–4 (1954) In Russian.

The equation

$$c_2c_3^2/c_1^2 = pK(T)\exp\{-4\pi d^2e^2p_I/3(kT)^3r_0\}$$

has been derived (mathematics not given) for the effect of ions (e.g. in a glow discharge) on the concentration of NH_3 produced from $N_2 + 3H_2$; here c_1, c_2 and c_3 are, respectively, the concentrations of NH_3, N_2 and H_2, d is the dipole moment of NH_3, r_0 and e are the ionic radius and charge, $pK(T)$ is the equilibrium constant for ammonia synthesis, and p_I is the partial pressure of the ion. R. C. MURRAY

541.124

6565. Relation between the surface potential and the interaction energy in the case of some hydrogen films. J. C. P. MIGNOLET. Letter in *J. chem. Phys.*, **23**, *No.* 4, 753 (*April*, 1955).

The author compares the surface potential (defined by $V = -\Delta\phi$, where $\Delta\phi$ is the change in work function), the differential energy of interaction (Δq) and the integral energy of interaction (ΔQ) for hydrogen films in the systems WH, NiH and FeH. For nearly complete films he finds $\Delta q/V = 1{\cdot}10 \pm 0{\cdot}16$; $\Delta Q/V = 0{\cdot}47 \pm 0{\cdot}11$; $\Delta q/\Delta Q = 2{\cdot}46 \pm 0{\cdot}36$ electrons per atom respectively. Within the accuracy of the data these quantities agree with the relations: $\Delta q = eV$; $\Delta Q = eV/2$; $\Delta q = 2\Delta Q$, where e is the electronic charge. These findings do not agree with those of Boudart [*J. Amer. Chem. Soc.*, **74**, 3556 (*July* 20, 1952)]. The reasons for the difference are discussed and new interpretations are put forward for the above relations. J. IBALL

541.124

6566. Charge transfer reactions in monatomic and diatomic gases. J. A. DILLON, JR, W. F. SHERIDAN, H. D. EDWARDS AND S. N. GHOSH. *J. chem. Phys.*, **23**, *No.* 5, 776–9 (*May*, 1955).

Cross-sections for charge-transfer reactions between ions and neutral atoms and molecules have been measured in the energy range from 50 to 850 eV. Charge transfer cross-sections for symmetrical reactions in monatomic and diatomic gases increase with increasing viscosity cross-sections. The charge-transfer cross-sections decrease with increasing incident ion energy in conformity with the adiabatic criterion. For reactions in diatomic gases the charge-transfer cross-sections decrease as the changes in internuclear distance for the processes increase. A.

541.124

6567. Reactions of $Hg(^3P_1)$ with toluene. A. H. SEHON AND B. DEB. DARWENT. *J. chem. Phys.*, **23**, *No.* 5, 822–5 (*May*, 1955).

The reactions between $Hg(^3P_1)$ and toluene have been investigated between 150 and 400°C at pressures from 0·4 to 30·5 mm Hg. The gaseous products are H_2, CH_4 and C_2H_6. The quantum yield for H_2 is 5×10^{-4} at 150°C and increases to about 10^{-1} at 400°C. A mechanism based on two types of excited toluene molecules is proposed. A.

541.124 : 539.13

Method of calculating cross-sections for molecular collisions. *See Abstr.* 6350

541.126 : 537.525.8

6568. Reactions of nitrogen activated by electric discharge. R. N. VARNEY. *J. chem. Phys.*, **23**, *No.* 5, 866–8 (*May*, 1955).

For gaseous reactions of nitrogen with hydrogen or with oxygen, it was necessary to pass only the nitrogen through a glow discharge, the other gas being admitted at a later point in the flow line. Ammonia, nitrous oxide and dinitrogen trioxide were formed, respectively. By suitable control of fields it was established that nitrogen ions were playing no direct rôle in the reactions but rather a neutral form of activated nitrogen in every case. Passing the hydrogen or oxygen alone through the discharge and then admixing nitrogen yielded no reaction product at all. Several further results indicated that ionic processes on the whole are not active in gas discharge reactions. A.

541.127

6569. Method of integrating the rate equations for free radical initiated polymerizations. J. P. HOWE. *J. chem. Phys.*, **23**, *No.* 5, 889–902 (*May*, 1955).

A method is given for integrating the equations for the rate of polymerization reactions without the assumption of steady states for the concentrations of the various free radicals. The main reaction steps used are: free radical production, chain propagation, chain transfer and chain termination. Explicit expressions are found for the total amount of polymer, the number average, and the weight average as a function of time for the particular case of free radicals produced initially by a pulse of light. Other modes of dependence on time for the primary free radicals may also be treated. A.

541.127

6570. Mixing machine of high precision for study of rapid reactions. W. R. RUBY. *Rev. sci. Instrum.*, **26**, *No.* 5, 460–2 (*May*, 1955).

The mixing machine described was designed for use in the study of certain rapid reactions by the steady-state-of-flow method. This machine combines several features not previously described for a single machine. (1) It may be used for reactions whose range of half-reaction times varies from 6 msec to 1·6 sec. This wide range is obtained by varying syringe piston speed to change the velocity of flow and by inserting spacer units to increase the length of reaction path. (2) It give results of high precision when used with the "chemical stop" method. The combination of precision-machined syringes and sensitive sampling and timing mechanism gives data from which precise calculations of velocities of flow and reaction time can be made. (3) The combination of three separate mixing chambers with or without spacer units enables one to premix sensitive reagents, immediately before initiating the primary reaction. The performance of the machine was evaluated by measuring the rates of a first-order reaction using the steady-state-flow technique. A.

541.128

6571. The magneto-catalytic effect of ortho-para-hydrogen conversion in nickel catalysts. G. VIETH. *Z. Naturforsch.*, **10a**, *No.* 4, 330–9 (1955) In German.

In a preceding paper [Abstr. 589 (1954)] Justi and Vieth investigated the influence of external magnetic fields upon the catalytic activity of ferromagnetic substances. The reaction $p\text{-}H_2 \rightarrow n\text{-}H_2$ was chosen for this study because it cannot lead to secondary chemical products which might be deposited upon the catalyst, thereby altering its surface. In spite of this elimination of systematic esperimental errors a considerable margin of errors still persisted owing to seemingly uncontrollable temporal fluctuations of the activity of the catalyst caused by the necessary interruptions of the gas stream. These fluctuations may, in the relatively long time-intervals lapsing between consecutive withdrawals of samples for static analysis, simulate spurious systematic effects. Therefore the thermal method for measuring and registering concentrations of *p*- and *o*-hydrogen was further developed in such a way that the values are measured and registered in time-intervals short enough for a practically continuous curve to be obtained, which no longer needs any arbitrary interpolation. The increase of accuracy thus achieved was used in the first instance for a renewed study of the Hedvall effects, i.e. the alterations of the activity of nickel in the Curie interval. The diagrams obtained show with great certainty that the activation energy and the frequency factor of the p–n-H_2 conversion are smaller above than below the Curie temperature of nickel. This result is in line with the known behaviour of the adsorption of hydrogen in the transition from para- to ferromagnetism. When studying other reactions, e.g. decomposition of N_2O and formic acid Hedvall *et al.*, have observed an increase of the activation energy and of the temperature coefficient when transgressing the Curie temperature. This difference between their and our findings is nevertheless quite in line with Hedvall's perception of the basic changes in the catalyst underlying the phenomena observed and becomes understandable if the results of Suhrmann and Sachtler are considered, who show that alterations of the energy of electron emission may have widely differing effects upon the activation of reactions with electronegative and electropositive adsorbates respectively. A.

ELECTROCHEMISTRY 541.13

541.132

6572. Counter-ion distribution in dilute solutions of rigid spherical macromolecular ions in the absence of added salt. H. FUJITA. *J. chem. Phys.*, **23**, *No.* 5, 837–46 (*May*, 1955).

The electrostatic potential field and the accompanying counter-ion distribution in dilute solutions of rigid spherical-polyelectrolyte ions in the absence of added salt is calculated on the basis of an approximate Poisson–Boltzmann equation. The exact Poisson–Boltzmann equation is approximated so that its characteristic non-linearity is conserved properly, and the non-linear equation thus obtained is solved rigorously under relevant boundary conditions. The calculated results reveal a strong tendency of the counter-ions to cluster near the macro-ion, and this occurs even at such extremely low concentrations of

the solution as would be beyond the limit of experimental investigation. It is shown that the zeroth-order approximation (in which the basic equation is linear) gives unexpectedly good solutions for the potential distribution even at a fairly high degree of ionization of the macro-ion, but leads to incorrect results for the counter-ion distribution except at a very low degree of ionization. A.

541.133 : 545.37

6573. Equivalent circuit for a coil cell used in *rf* titrimetry. J. R. HASKINS, G. HELLER AND E. MILLER. Letter in *J. chem. Phys.*, **23**, *No.* 4, 755–6 (*April*, 1955).

The variation of cell conductance of a coil cell with frequency, found [Abstr. 8732 (1954)] to depend on the properties of the liquid in the cell, is explained on the basis of an equivalent circuit. W. GOOD

541.135 : 536.7

6574. Calculation of thermodynamic properties of polyelectrolytes. R. A. MARCUS. *J. chem. Phys.*, **23**, *No.* 6, 1057–68 (*June*, 1955).

Expressions are derived which introduce an appreciable simplification into the calculation of the thermodynamic properties of solutions of polyelectrolytes in certain cases. For example, for a certain class of theoretical models of these systems it is found that the square of the mean ion activity coefficient of a uni-univalent salt in the presence of polymeric ions is $V^2/\int e^{-e\psi/kT}dV.\int e^{e\psi/kT}dV$, the integration of the potential ψ being over a region whose volume is the volume of solution per macro-ion, V, and whose symmetry is that assumed for the polyelectrolyte. The osmotic pressure of a salt-polyelectrolyte system is, ignoring the contribution of the macro-ion, estimated to be $\Sigma_i c_i^s kT$, where $\Sigma_i c_i^s$ is the sum of the concentrations of all ions at the surface bounding the previously defined volume V. Other relations and various applications are given. The activity coefficient of salt in the presence of polyelectrolytes, calculated by extending the "parallel rod" picture of polymeric ions, is found to be in reasonable agreement with the experimental data. The use of the Poisson–Boltzmann equation to estimate ψ in these systems is shown not to render inconsistent several alternative expressions for the electrostatic contribution to the free energy. A.

541.135.5

6575. New method for the kinetic study of fast electrode reactions. T. BERZINS AND P. DELAHAY. Letter in *J. chem. Phys.*, **26**, *No.* 5, 972 (*May*, 1955).

The kinetics of electrode processes involving a single rate-determining step are characterized by a rate constant which (as large in value as 1 000 cm sec^{-1}) can be determined from the voltage–time curves of an electrolysis produced by a current impulse. W. GOOD

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.14

6576. Photochemical decomposition of aqueous permanganate ion. G. ZIMMERMAN. *J. chem. Phys.*, **23**, *No.* 5, 825–32 (*May*, 1955).

Quantum yields for the photochemical decomposition of aqueous MnO_4^- have been measured under a variety of conditions using a sensitive method for measuring O_2 production, first developed by Pringsheim and co-workers. The quantum yield was found to depend strongly on the wavelength of the light, slightly on temperature at the longer wavelengths, and not at all on the composition of the solution or on light intensity. Additional experiments were carried out which showed that the isotopic composition of photochemically produced O_2 was independent of the O-isotopic composition of the solvent water. These results lead to the conclusion that the radiant energy absorbed by the MnO_4^- ion is converted with high probability into vibrational energy of the ground state, after which the ion dissociates thermally into MnO_2 and O_2 (in a single act) or cools down without dissociation (the position of the extra electron is uncertain). A possible quantitative theory which predicts fairly successfully the dependence of the quantum yield on wavelength is outlined. A.

541.144

6577. Vacuum photolysis of silver bromide and silver chloride. G. W. LUCKEY. *J. chem. Phys.*, **23**, *No.* 5, 882–90 (*May*, 1955).

The quantum yields of halogen production in the vacuum photolysis of silver bromide and silver chloride have been measured at various temperatures, wavelengths, and light intensities. Silver–bromide crystals containing small amounts of copper and cadmium bromide have also been studied. At room temperature, the yields of thick crystals follow the equation, $\psi = Q(1 - e^{-ka})$, where Q is the surface efficiency, k is the absorption coefficient, and a is a parameter which is defined below. At room temperature, in the halogen evolution range studied, the value of a for silver bromide is about $0{\cdot}4\mu$ and that for silver chloride is about $0{\cdot}24\mu$. The values of Q are usually between 0·5 and 1·0. The quantum yield of halogen production at room temperature is similar to the yield of a fast wall reaction. Both depend on the diffusion of reactants to the surface. The parameter a is related to the thickness of the diffusion layer. A numerical solution of the diffusion equation by C. A. Duboc has shown that $a = 1{\cdot}154D^{\frac{1}{2}}/k_1^{\frac{1}{2}}k_1 I_0^{\frac{1}{2}}$ where D is the diffusion coefficient of positive holes and electrons k_1 is the recombination coefficient of positive holes and electrons in the silver halide, and I_0 is the incident intensity of light. Above a certain temperature, the quantum yields decrease with increasing temperature, the long-wavelength yields increase relative to those at short wavelength and the yields increase with increasing light intensity. These effects are inhibited by the addition of copper bromide to silver–bromide crystals. The decrease in yield at high temperatures is probably caused by the decreased effectiveness of traps. The cadmium results indicate that this decrease is also affected by the ionic conductivity of the crystals. The addition of copper or cadmium ion does not have a large effect on the quantum yields at room temperature. This indicates that positive-ion vacancies in the silver halides are not good positive hole-traps at room temperature. The data and the solution of the diffusion equation indicate that the quantum yield of photoconductivity

and photolysis are closely related. Additional measurements of photoconductivity and light-absorption coefficients are needed before the results can be completely interpreted. A.

541.15

6578. Radiation induced equilibrium of hydrogen-deuterium mixtures. S. O. THOMPSON AND O. A. SCHAEFFER. Letter in *J. chem. Phys.*, **23**, *No.* 4, 759–60 (*April*, 1955).

In order to explain a 12% discrepancy previously reported between the experimental and the theoretical value of the equilibrium constant of this reaction, it has been suggested that the constant might be affected by the radiation field. This was investigated by the direct mass-spectrometric comparison of mixtures in equilibrium prepared by radiation and catalytically. No appreciable difference was found between the two kinds of mixtures and the values of the equilibrium constants agreed with the theoretical value. It is therefore unlikely that this value is influenced by the radiation. A. J. TAYLOR

541.15

6579. Decomposition of carbon dioxide by ionizing radiation. I. P. HARTECK AND S. DONDES. *J. chem. Phys.*, **23**, *No.* 5, 902–8 (*May*, 1955).

The irradiation of gaseous carbon dioxide with radon or in a nuclear reactor, produces about 0·1% decomposition of primarily dissociated carbon dioxide, correlating with previous results in the literature. The irradiation of solid carbon dioxide with radon produces carbon monoxide and oxygen with a *G*-value of 9 to 10. The irradiation of gaseous carbon dioxide, containing a small amount of nitrogen dioxide, by radon or in a nuclear reactor, produced carbon monoxide and oxygen, with a *G*-value of 9 to 10. Percentages as small as 0·5% of nitrogen dioxide are sufficient to stop the back reaction to carbon dioxide. A new mechanism has therefore been proposed for the ineffectual decomposition of carbon dioxide by ionizing radiation, and the effective decomposition when nitrogen dioxide is present. With the proposed mechanisms, the classical experiments of Lind, the carbon monoxide oxidation and the carbon monoxide decomposition, are quantitatively explained. A.

541.15

6580. Changes in silicone polymeric fluids due to high-energy radiation. A. CHARLESBY. *Proc. Roy. Soc. A*, **230**, 120–35 (*June* 7, 1955).

When subjected to high-energy radiation, polydimethyl siloxanes can be cross-linked to form insoluble amorphous structures which are transparent and have marked rubber-like properties. Data are given on the relation between molecular weight and bulk viscosity, which is often used to characterize these polymers. The relationship between cross-linking density and radiation dose is deduced from the changes in both solubility and fusibility, and is confirmed by elastic measurements. Unit pile radiation is found to produce cross-linking in about 2·2% of the monomer units. Details are given of the change in solubility and swelling with radiation dose and of the mechanism of cross-linking. The energy per cross-link is about 32 eV, and is independent of molecular weight. A brief comparison is made with cross-linking in hydrocarbon polymers. A.

541.15

6581. Radiation protection in copolymers of *iso*-butylene and styrene. P. ALEXANDER AND A. CHARLESBY. *Proc. Roy. Soc. A*, **230**, 136–45 (*June* 7, 1955).

The effect of ionizing radiations on copolymers of *iso*butylene and styrene has been studied. Molecules consisting only of *iso*butylene units degrade under radiation, whereas styrene polymer cross-links. In the copolymer the styrene units offer protection against radiation to the neighbouring *iso*butylene units. An estimate is given for the extent of this protection. On irradiation the copolymer at first degrades to an extent which depends on the percentage of styrene, then it cross-links partially into a gel. Even for copolymers containing 80% of styrene, protection is only partial, and after high radiation doses specimens separate into a gel and a sol fraction. It is not possible to cross-link such copolymers sufficiently to produce a completely insoluble material. Chemical analysis of the irradiated copolymer shows that the separate units are distributed approximately at random throughout the material, and do not occur in large blocks rich in styrene or *iso*butylene. A.

DISPERSIONS . COLLOIDS . ADSORPTION

541.18

541.18.043

6582. Modifications to a sedimentation apparatus. J. KOBAK. Letter in *J. sci. Instrum.*, **32**, *No.* 4, 153–4 (*April*, 1955).

Simple modifications to the apparatus described by Stairmand [*Transactions of the Institution of Chemical Engineers and Society of Chemical Industry. Symposium on Particle Size Analysis*, p. 128 (1947)] improve its accuracy down to a particle size of about 2μ. W. GOOD

541.18.043

6583. A centrifuge permitting continuous observation of the spinning tube. B. B. MARSH. *J. sci. Instrum.*, **32**, *No.* 6, 205–6 (*June*, 1955).

A description is given of a few simple modifications to a centrifuge to allow the observation of a spinning tube. The volumes of the separate phases within the tube can be read directly and continuously during centrifugation. A.

541.183

6584. Thermal accommodation coefficient of helium on a bare tungsten surface. L. B. THOMAS AND E. B. SCHOFIELD. *J. chem. Phys.*, **23**, *No.* 5, 861–6 (*May*, 1955).

The accommodation coefficient of helium on a presumably clean tungsten surface is determined from 83 to 303°K. A getter technique is applied in which, after thorough baking of the tube and vacuum system, aluminium is evaporated in vacuum over the inner walls of the measuring tube. The technique appears to be superior to the circulation over charcoal used by Roberts. Clean surface values of the accommodation coefficient, found by linear extrapolation to

time of flashing the filament, lie between 0·0151 and 0·0172 (with small positive corrections probably to be applied). The variation with temperature is small and the values themselves are much lower than any heretofore reported. A.

541.183

6585. On the logarithmic rate law in chemisorption and oxidation. P. T. LANDSBERG. *J. chem. Phys.*, **23**, *No.* 6, 1079–87 (*June*, 1955).

It is shown that the logarithmic rate law is found very widely in chemisorption and oxidation. A theory of this law is offered, and comparison with experiment leads to reasonable values for the parameters. Although the theory is very elementary, it is hoped that the physical interpretation it provides of experimentally determined parameters will encourage a more detailed study of these, for instance as a function of temperature and ambient pressure. A.

541.183 : 536.7

6586. A thermodynamic study of the adsorption of benzene vapour by active charcoals. D. H. EVERETT AND W. I. WHITTON. *Proc. Roy. Soc. A*, **230**, 91–110 (*June* 7, 1955).

Reports a study of the thermodynamics of adsorption and of adsorption hysteresis in the system. Four charcoals of differing activity were examined at five temperatures in the range 15 to 35°c. Heats and entropies of adsorption and desorption are derived from these measurements and interpreted in terms of the processes occurring during adsorption and desorption. The data are used to discuss the significance of current theories of adsorption and hysteresis, and a simple model is described which is consistent with the thermodynamic data. More detailed specification of the model requires further experimental and theoretical study. A.

CHEMICAL STRUCTURE 541.2/.6

541.57

6587. One-dimensional model of the hydrogen bond. E. R. LIPPINCOTT AND R. SCHROEDER. *J. chem. Phys.*, **23**, *No.* 6, 1099–106 (*June*, 1955).

A model is proposed based on the potential function $V = D[1 - \exp(-n\Delta r^2/2r)]$. The energy associated with both the weak and strong bonds of the configuration $RO - H - - - OR$, is obtained through application of this function. A repulsive Van der Waals potential and an attractive electrostatic potential are also assumed to exist between the two electronegative atoms of the hydrogen bond. Through application of the conditions describing a stable equilibrium, relations are obtained which permit a calculation of OH frequency shifts, OH bonded distances, hydrogen bond energies and k_{O---O} force constants, all as a function of the $O - - - O$ distance R. The calculated quantities agree well with those obtained from neutron diffraction, infrared, and other experimental studies. Because of the assumptions involved this model is best used to describe the properties of hydrogen bonds in crystals. The model is also capable of extention to describe the properties of other types of hydrogen bonds such as HFH, NHN, NHO, OHN, etc. A.

541.64

6588. Studies in chain-transfer. Phenylazotriphenyl methane catalysed polymerisation of styrene in toluene. R. N. CHADHA AND G. S. MISRA. *Indian J. Phys.*, **28**, *No.* 12 (*Dec.*, 1954) = *Proc. Indian Assoc. Cultiv. Sci.*, **37**, 37–40 (*Dec.*, 1954).

A study of the chain transfer reaction between growing styrene (M) polymer radical and toluene (S), when catalysed by phenylazotriphenyl methane (B). It has been shown that the transfer constant from the slope of $1/\bar{P}$ against S/M plots at constant B/M values is not appreciably affected by the presence of low concentrations of the catalyst and initiation reaction was found to be bimolecular. A.

541.64 : 530.162

6589. Statistical mechanics of polymer solutions. I–II. M. KURATA, M. TAMURA AND T. WATARI. *J. chem. Phys.*, **23**, *No.* 6, 991–1003 (*June*, 1955).

Some contributions are made to the refining of the lattice model theory of Flory of chain polymer solutions by introducing the idea used in the recent theory of regular assembly that combinatory factor constructed in terms of multiple site clusters can be properly used to take long-range correlations between a given site and its far distant neighbours into account. In Pt I, the combinatory factors of Flory and others in current use are reconstructed to exemplify the pseudo-assembly method which has been presented by Kikuchi and the present authors for an easy construction of combinatory factors of higher-order approximation for regular assembly, and to give a thorough understanding of the succeeding uses in Pt II. In Pt II, a refined theory of chain polymer solutions is developed. The final expressions for the entropy of dilution and the osmotic pressure depend on the flexibility and the degree of branching of the polymer chain, and give a better agreement with observed data even at high dilution. A.

541.64 : 532.133

6590. Intrinsic viscosity of polymethylmethacrylate. A. PETERLIN. Letter in *J. chem. Phys.*, **23**, *No.* 4, 750–1 (*April*, 1955).

Intrinsic viscosity $[\eta]$ has been measured in different solvents over a very wide range of molecular weights M by Schulz [K. G. Schön and G. V. Schulz, *Z. phys. Chem.* [*Frankfurt a.M.*] **2**, 197 (1954)]. For large values of M, a graph of log $[\eta]$ against log M gives a straight line in good agreement with theory. For low values of M this is not the case. A model of polymethylmethacrylate is considered which gives good agreement for both high and low molecular weights.

H. G. JERRARD

CHEMICAL ANALYSIS 543/545

545.8

6591. Proton magnetic resonance spectra of coals. P. C. NEWMAN, L. PRATT AND R. E. RICHARDS. Letter in *Nature* [*London*] **175**, 645 (*April* 9, 1955).

A reduction of the second moment of the proton resonance of coal from 21·5 to 16 $(\text{gauss})^2$ with increase of coal rank is interpreted as indication of an increased proportion of aromatic H atoms.

D. H. WHIFFEN

545.82 : 538.222

6592. Nuclear magnetic resonance spectroscopy. J. N. SHOOLERY. *Analyt. Chem.*, **26**, *No.* 9, 1400–3 (*Sept.*, 1954).

Fundamental concepts of nuclear magnetic resonance are discussed and the basic equation relating magnetic field and radio-frequency is derived. The types of apparatus in general use are described. Applications which can be accomplished using fields of moderate homogeneity are quantitative determinations of the number of nuclei of a given type, illustrated by the measurement of moisture. Nuclear magnetic resonance spectroscopy in extremely homogeneous fields is taken up and the various effects which are encountered are explained. Applications to research are found in molecular electron distribution, structure determination, organic group identification, and in general studies of the structural features of organic compounds, fluorocarbons, silicones, boranes, and compounds of phosphorus. High-resolution spectra illustrate some of these applications. A.

545.823 : 535.247.4

6593. New fluorescence photometer. F. J. LYNCH AND J. B. BAUMGARDNER. *Rev. sci. Instrum.*, **26**, *No.* 5, 435–40 (*May*, 1955).

An instrument for microanalytical analysis by a fluorescence method which is sensitive, linear and stable is described. Both an unknown and a reference sample of the same constitution are excited to fluorescence by ultraviolet light emitted in pulses by an a.c. powered mercury arc lamp. The resulting pulsed fluorescent light from each sample is incident on a separate vacuum phototube. The ratio of the fundamental a.c. components of the photoelectric currents flowing in the two phototubes is measured automatically by a servomechanism. In such a system, the measurement is independent of the intensity of the exciting ultraviolet light, the thermionic currents of the two phototubes, and the temperature of the fluorescent samples. A simplified optical system provides good efficiency. Either solid or liquid samples may be rapidly measured. For uranium analysis the instrument may be calibrated to read full scale for 5×10^{-10}, 5×10^{-9}, 5×10^{-8}, and 5×10^{-7} g of uranium. Although it is designed primarily for uranium analysis, the filters may be changed to permit measurement of other materials which can be analysed by fluorescence methods. A.

545.827

6594. Radioactivation analysis of arsenic in silicon. J. A. JAMES AND D. H. RICHARDS. *Nature* [*London*] **175**, 769–70 (*April* 30, 1955).

Describes application of neutron radioactivation to estimation of As contents between 0·001 and 3 p.p.m. The As carrier recovery yield was 80–90%; the detection limit is estimated as $3\cdot2\times10^{-10}$ g As, 3 days after irradiation. J. HAWGOOD

545.827 : 536.422

6595. Electron-induced water decomposition and its relation to mass spectrometric C_3^+ measurements in graphite vapor. D. A. HUTCHISON. Letter in *J. chem. Phys.*, **22**, *No.* 10, 1789–90 (*Oct.*, 1954).

Evidence is given for chemical formation of $(H_2O)_2^+$ and other molecular ions in the residual gases of a mass spectrometer ion source. Inconsistencies in the $C_1^+ : C_3^+$ ratio, observed in recent measurements in graphite vapour [Abstr. 3275, 7644 (1953)], are ascribed to $(H_2O)_2^+$ formation in water adsorbed in the source; similarly mass 38 peaks are ascribed to $(H_3O)_2^+$. It is pointed out that careful investigation of possible electron-induced secondary reactions is necessary before any molecular ion structure can be assigned to a given observed mass. N. M. KING

545.827 : 536.422

6596. Water dimer and its relation to mass spectrometric measurement of C_3^+ in carbon vapor. W. A. CHUPKA AND M. G. INGHRAM. Letter in *J. chem. Phys.*, **23**, *No.* 1, 203–4 (*Jan.*, 1955).

The suggestion of Hutchison (preceding abstract) that the mass 36 peak ascribed to C_3^+ was in fact due to $(H_2O)_2^+$, is rejected, on grounds of sensitivity to C filament temperature and of the effect of shuttering off a Knudsen effusion cell. J. HAWGOOD

545.827 : 537.534.3

6597. Analytical mass spectrometry utilizing relative abundance ratios. J. B. FREEMAN AND E. J. SERFASS. *Analyt. Chem.*, **26**, *No.* 9, 1403–5 (*Sept.*, 1954).

Describes a mass spectrometric technique for the quantitative determination of binary mixture components which utilizes the relationship between relative abundance ratios of mass ion currents and sample composition. Special circuits have been added to a 60-degree directional focusing mass spectrometer which enable it to measure ion current ratios directly or to function as a conventional mass analyser. A unique feature is the use of a modulated accelerating potential to produce modulated ion currents from two widely separated masses which can then be focused on a single exit slit of the spectrometer tube. Analyses of several binary mixtures performed with this instrument gave results accurate to within 1% which were independent of instrument sensitivity, pressure or volume measurements, and did not necessitate involved calculations. A.

545.827 : 542.923

6598. Mass spectrometric detection of free OH radicals in the thermal decomposition products of H_2O vapour. T. TSUCHIYA. Letter in *J. chem. Phys.*, **22**, *No.* 10, 1784–5 (*Oct.*, 1954).

Free OH radicals were detected with a mass spectrometer by the subjection of H_2O vapour to pyrolysis on a platinum filament. The effects of heating of the filament were investigated: it was found that the appearance potentials of OH^+ and H^+ decrease considerably, but no change occurs in the H_2O^+ curve. New particles such as OH radicals must be formed thermally. A. J. TAYLOR

CRYSTALLOGRAPHY 548

548.5

6599. Note on an analytical proof of Wulff's theorem in three dimensions. G. C. Benson and D. Patterson. *J. chem. Phys.*, **23**, *No.* 4, 670–2 (*April*, 1955).

A proof of Wulff's theorem for the equilibrium shape of a two-dimensional crystal has been given by Burton, Cabrera and Frank [Abstr. 6560 (1951)]. This has been extended to three dimensions in the present note and an expression has been derived for the principal radii of curvature of the crystal. A.

548.5

6600. Influence of impurities on the growth of quartz crystals from flint and quartzite. C. S. Brown, R. C. Kell, P. Middleton and L. A. Thomas. Letter in *Nature* [*London*] **175**, 602–3 (*April* 2, 1955).

The hydrothermal technique for the growth of large quartz crystals which is usually used with melting-quality quartz can also be applied to flint and to quartzites. As source materials the latter fall into two classes, A and B. Class A behaves as melting-quality quartz, but Class B and flint require, for the production of good crystals, the addition of sodium hydroxide and sodium fluoride to the aqueous solution of sodium carbonate. Results of various experiments of the authors indicate that the distinction between the behaviour of the materials is due to the presence of small amounts of Al in the minerals and to the influence of the hydrothermal conditions on the degree of ordering of the Al and Si atoms in the crystal lattices. S. WEINTROUB

548.5

6601. Study of crystalline orientation phenomena by electron diffraction and simultaneous ionic attack. J.-J. Trillat, N. Terao, L. Tertian and H. Gervais. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 14, 1557–9 (*April* 4, 1955) In French.

Orientated overgrowths of gold on rock salt cleavage faces were examined by electron diffraction while at the same time the gold layer was being gradually removed by sweeping it with an ionic beam. The depth and nature of the epitaxial growth could thus be explored. A.E.I. RESEARCH LABORATORY

548.51

6602. Nucleation of ammonium iodide crystals from aqueous solutions. J. B. Newkirk and D. Turnbull. *J. appl. Phys.*, **26**, *No.* 5, 579–83 (*May*, 1955).

Ammonium iodide crystals nucleate at a sensible rate in small drops (10–50μ dia.) of solution only if the supersaturation ratio S equals or exceeds a value of 1·21. This critical supersaturation ratio corresponds to an interfacial energy σ between ammonium iodide crystals and solution equal to or greater than 15·4 erg/cm^2. However, for sensible nucleation of NH_4I on a freshly cleaved surface of one of the mica minerals, S is related to the disregistry δ between atom sites on the mica surface and the atom sites on a {111} plane of NH_4I. This dependence can be described by the equation $\ln S = 3{\cdot}8\delta^2 + 0{\cdot}0059$. This equation is in agreement with the theory of Turnbull and Vonnegut relating disregistry to the potency of nucleation catalysts. However, the coefficient of δ^2 is about 1 to 2 orders of magnitude smaller than the theoretical expectation. Results are consistent with Bradley's hypothesis that S, for sensible 2-dimensional nucleation of NH_4I on its own perfect {111} planes, is remarkably small, viz. $S \simeq 1{\cdot}01$. A.

548.574

6603. The influence of dislocations and impurities on the distribution and size of etch-figures on pure aluminium. G. Wyon and P. Lacombe. *Defects in crystalline solids* [*Bristol*] 187–96. See Abstr. 5707 (1955).

It is found that the density of etchpits in super-purity Al is dependent on the Fe content. Heat treatment may lead to depleted zones near grain boundaries, in which no etching occurs, and elsewhere to an increase in density of etchpits as the Fe concentrates on the dislocations. Grain boundary migration occurs at low temperatures when impurities in the boundaries are important. It is concluded that purity as well as dislocation density is important in determining the etched structure. W. M. LOMER

ATOMIC AND X-RAY CRYSTALLOGRAPHY 548.7

548.7 : 538.22

6604. Theory of ionic ordering, crystal distortion, and magnetic exchange due to covalent forces in spinels. J. B. Goodenough and A. L. Loeb. *Phys. Rev.*, **98**, *No.* 2, 391–408 (*April* 15, 1955).

Elastic- and electrostatic-energy considerations are insufficient for an explanation of cation ordering between tetrahedral and octahedral sites in spinels. Tetrahedral, octahedral and square covalent bonds are also important when cations are to be accommodated in these sites. The square bonds in octahedral sites can cause the tetragonal distortion observed in Mn_3O_4, γ-Mn_2O_3, $ZnMn_2O_4$, $CuFe_2O_4$, $CuCr_2O_4$, $CaIn_2O_4$, $CdIn_2O_4$ and metallic indium. A new magnetic exchange mechanism, "semicovalent exchange," which is consistent with the covalent model, is used to explain the magnetic properties of spinels. A.

548.7

6605. Axial ratios in hexagonal crystals. J. W. McClure. *Phys. Rev.*, **98**, *No.* 2, 449–61 (*April* 15, 1955).

A theoretical study has been made of the deviations of the axial ratios of hexagonal metal crystals from the ideal close-packing value, both for pure metals and alloys. The deviation is expressed in terms of the "effective stress" which would tend to change the axial ratio in the close-packed configuration, and the observed elastic constants. Using a change of scale procedure, a formula for the "effective stress" is derived in terms of integrals over the electronic wavefunction in the close-packed configuration. When the Hartree–Fock approximation is used to evaluate the expression for the "effective stress," three contribu-

tions are found: (1) a "kinetic stress," (2) an "electrostatic stress," and (3) an "exchange stress." Estimates of each term for pure beryllium indicate that (1), which resembles the effects estimated by Jones and Goodenough, is most important; (2) is negligible; and (3) may be appreciable. It is found that the change in axial ratio with alloying is due to a different mechanism from that proposed by Jones. However, an argument is presented which leads to qualitatively the same conclusions as his concerning the connection between the change in axial ratio and the band structure. A.

548.7 : 535.347

6606. First approximation theory of the exciton spectrum of a uniaxial crystal. S. Nikitine. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 13, 1415–17 (*March* 28, 1955) In French.

Mott's theory on the excitation spectrum is extended to uniaxial crystals and *s,p,d*-levels are calculated in first-order approximation. The results are applied to HgI_2 and could explain the dichroism.

C. TURNER

548.7

6607. Theory of the lower excited electronic states of the benzene crystal. D. Fox and O. Schnepp. *J. chem. Phys.*, **23**, *No.* 5, 767–75 (*May*, 1955).

For the two lowest exciton bands of benzene, calculations have been carried out for the bandwidths and for the energies of the levels to which dipole transitions from the ground state are allowed. Expressions have been derived for the intensities of crystal transitions corresponding to both allowed and forbidden molecular transitions and have been applied to the case of the benzene crystal. Comparison is made with available experimental data and additional experiments are suggested so that further comparison may be made. From the bandwidths, evidence is obtained that the lowest excited state of the benzene molecule belongs to the B_{2u} representation of the molecular group, D_{6h}. A.

548.7

6608. Some examples of position-correlation of electrons in crystal structures. K. Schubert. Letter in *Acta cryst.*, **8**, *Pt* 5, 289–90 (*May*, 1955) In German.

The fact of position-correlation throws light on some structures; those of gallium, black phosphorus and SiS are discussed. A. R. STOKES

548.7

6609. The improbability of self-trapping of electrons in a perfect crystal lattice. H. Haken. Note in *Z. Naturforsch.*, **10a**, *No.* 3, 253–4 (1955) In German.

548.7

6610. Nuclear magnetic resonance studies of defects in ionic crystals. M. H. Cohen and F. Reif. *Defects in crystalline solids* [*Bristol*] 44–51. See Abstr. 5707 (1955).

The nuclear resonance of AgBr and of AgBr with substituted $CdBr_2$ impurity is studied. The results show the increase in line width with temperature in pure AgBr. Temperature effects are much more marked in the $CdBr_2$ doped crystals and indicate a pairing of Cd^{2+} and associated lattice vacancies at lower temperatures. G. F. J. GARLICK

548.7

6611. The optical effects of radiation damage in diamond and quartz. R. W. Ditchburn, E. W. J. Mitchell, E. G. S. Paige, J. F. Custers, H. B. Dyer and C. D. Clark. *Defects in crystalline solids* [*Bristol*] 92–107. See Abstr. 5707 (1955).

Electron bombardment of diamonds produces new absorption bands (2·0eV and ≃3–4eV) showing considerable fine structure particularly when bombardment is carried out at low temperatures. Heating the crystal decreases the 2eV and 3·5eV bands but a new band at 2·6eV appears, thought to be due to interstitial C_2 pairs. An emission spectrum corresponding to the new band is also measured. In quartz neutron bombardment increases u.v. absorption (≃5·5eV) but the visible absorption (≃1·8–3eV) produced decreases with prolonged irradiation. Heating or u.v. illumination bleaches the neutron induced bands. The u.v. band is associated with atomic displacements created by neutrons. X-ray bombardment does not increase their number. Dependence of absorption bands on Al impurity is indicated. G. F. J. GARLICK

548.7 : 539.169

6612. Radiation disarrangement of crystals. J. S. Koehler and F. Seitz. *Defects in crystalline solids* [*Bristol*] 222–31. See Abstr. 5707 (1955).

A general discussion of the interpretation of experimental facts is given. There is general agreement between theoretical estimates of numbers of displaced atoms and measured resistivity increases. Tentative explanations of radiation annealing, and of the successive stages of thermal annealing are given, but it is clear that further experimental work is necessary. W. M. LOMER

548.7

6613. Sub-structures and networks of dislocations in face-centred cubic metals. T. Suzuki and T. Imura. *Defects in crystalline solids* [*Bristol*] 347–58. See Abstr. 5707 (1955).

Hexagonal columnar mosaic structures parallel to ⟨111⟩ directions are expected in f.c.c. metals. These have been observed in Al 3% Mn and Al 7% Mn alloys by chemical etching techniques. Evidence that diffusion of solutes along dislocations may assist precipitation is given. W. M. LOMER

548.7 : 539.4.016

6614. Work hardening in copper crystals. T. H. Blewitt, R. R. Coltman and J. K. Redman. *Defects in crystalline solids* [*Bristol*] 369–82. See Abstr. 5707 (1955).

Slip lines have been observed at various strains; the length of a line is roughly inversely proportional to the strain. The residual resistivity is proportional to stress squared, the coefficient being slightly temperature dependent. At 4·2°K $\Delta\rho = 1{\cdot}3\times10^{-10}\sigma^2$ (σ in kg/mm² shear). About 25% of this change recovers below room temperature. Distinct evidence for twinning as a mode of deformation at 4·2°K was obtained. If the permanent change in resistivity is attributed to dislocations, a figure of $2{\cdot}3\times10^{-19}$ ohm. cm per cm of dislocation line is obtained, ~50 times theoretical estimates. W. M. LOMER

548.7

6615. Change in KCl lattice by soft X-rays. C. R. BERRY. *Phys. Rev.*, **98**, *No.* 4, 934–6 (*May* 15, 1955).

The lattice dimensions of powdered specimens of annealed and unannealed KCl were measured during irradiation by soft X-rays. One set of specimens was allowed to colour during irradiation and another group was prevented from colouring by simultaneous white-light illumination. The following observations were made: There was an increase in lattice dimension during exposure for every specimen. No difference existed for specimens which were coloured or not coloured. Saturation in the change in lattice dimension occurred at a lower exposure for the unannealed specimens than for the annealed specimens. The total increase in lattice dimension was about $\Delta a/a = 1\times10^{-5}$ for all specimens, compared with values given in the literature for maximum changes in length of approximately $\Delta l/l = 20\times10^{-5}$. The difference indicates production of void volume, presumably Schottky defects. The failure to observe a difference between coloured and uncoloured specimens may be caused by a considerably larger production of Schottky defects than of colour centres. A.

548.7

6616. Dynamic behavior of domain walls in barium titanate. E. A. LITTLE. *Phys. Rev.*, **98**, *No.* 4, 978–84 (*May* 15, 1955).

The nucleation and growth of 90 and 180° domains in barium titanate single crystals have been measured with optical techniques. Both types of domains nucleate as long thin wedges with an initial velocity of the order of 10^4 cm/sec for a driving field of 5 kV/cm. For 90° domains, detailed measurements of the nucleation rate as a function of time and field strength are given. After domains have been introduced into a crystal, their growth may be described in terms of wall motion. The 90° wall displacement depends strongly on strains and clamping of the crystal; wall motion appears to cease for frequencies in the megacycle range, where the piezoelectric resonances of the crystal set in. The sideways growth of 180° wedges is affected by the availability of neutralizing electric charges. Interaction of 180 and 90° domains may lead to 90° wall configurations with head-to-head or tail-to-tail orientation of the polar axes. A.

548.7 : 535.43

The scattering of light in sodium chloride non-crystals. *See Abstr.* 6055

548.7

6617. The after-effect of hydrostatic pressure on the color centers in alkali halides and calcium fluoride. R. KIYAMA, S. MINOMURA AND M. OURA. *Proc. Japan Acad.*, **30**, *No.* 8, 764–8 (*Oct.*, 1954).

The shifts of the absorption maxima due to hydrostatic pressure (7 500 atm) are tabulated for NaCl, KCl, KBr and KI coloured by electrolysis. Results for natural CaF_2 coloured by X-rays are also given.

J. E. CAFFYN

548.7

6618. Some experiments on the Z_2 band. G. CHIAROTTI, F. G. FUMI AND L. GIULOTTO. *Defects in crystalline solids* [*Bristol*] 317–20. See Abstr. 5707 (1955). Shorter version in *Nuovo Cimento Suppl.* (*Ser.* 10) **1**, *No.* 2, 112–13 (1955).

A study of Z-bands due to Sr^{2+} ions in KCl coloured at 600°c in Na vapour. Rapid cooling after coloration produces only the F-band, slow cooling produces the primary Z_2-band also. Prolonged heating at 110°c in dark enhances the latter band with decrease of the F-band. Thermal destruction of the Z_1-band to give the secondary Z_2-band depends on original rate of cooling after coloration. The Seitz model [Abstr. 7381 (1951)] explains the above effects.

G. F. J. GARLICK

548.7

6619. A theoretical study of the coloured alkali oxides. B. GRABE. *Ark. Fys.*, **9**, *Paper* 14, 229–43 (1955).

The sesquioxides of $Rb_4(O_2)_3$ and $Cs_4(O_2)_3$ are coloured. Most probably, the colour depends on the structure of the crystal lattice. To explain the dark colour the electron distribution of $Rb_4(O_2)_3$ is described in terms of semilocalized orbitals, an Rb atom and the three nearest O atoms being considered, assuming that the valence electron of Rb can be assigned to a molecular orbital of this group. The parameters of the orbital are determined by minimizing the energy of the electron. Two electronic states are obtained, having an energy difference between them which corresponds to a wavelength in the visible part of the spectrum. Thus a transition between these states can explain the colour of the crystal. A valence bond method is also discussed. A.

548.7

6620. Color centers in alkali halides containing NO_2^- ions in small concentration. E. HUTCHINSON AND P. PRINGSHEIM. *J. chem. Phys.*, **23**, *No.* 6, 1113–18 (*June*, 1955).

Alkali halide single crystals (KBr, KCl, NaBr and NaCl) containing NO_2^- ions at various concentrations, from 0·5 to 0·007 mole%, were grown by the Kyropoulos method. At high NO_2^- concentrations the typical NO_2^- band appears in the absorption spectrum with peak wavelengths between 280 and 260 $m\mu$ depending on the nature of the base material. The production of F-bands by exposure to X-rays is completely suppressed in these crystals at room temperature and greatly inhibited at −190°c. Instead of the F-band, a continuous band (C-band) is produced with a wavelength nearly coincident with the NO_2^- band, but not showing at low temperature the vibrational structure characteristic of the latter. Other less important new absorption bands appear in the red and the ultraviolet. At lower NO_2^- concentrations F-bands begin to appear in competition with the C-bands. The bleaching of the various absorption bands by light absorbed in them is investigated and discussed. NaCl seems to differ from the other halides in so far as in this crystal the production of the F-band is greatly enhanced by NO_2^- in concentrations which in KBr greatly inhibit the formation of F-centres. A.

548.73/.74

X-ray and electron investigation of materials. *See also under* "Structure of solids." Decimal classification 539.26/.27

548.733

6621. Apparatus for measuring complete single-crystal X-ray diffraction data by means of a Geiger counter diffractometer. T. C. Furnas, Jr and D. Harker. *Rev. sci. Instrum.*, **26**, *No.* 5, 449–53 (*May*, 1955).

A device for measuring X-ray diffractions from a single crystal is described. The heart of the apparatus is an "Eulerian Cradle," so named because it permits rotation of the crystal about each of the Eulerian axes. It is used for orienting single crystals in an X-ray beam, in order to bring each reciprocal lattice point into the equatorial plane for Geiger counter measurement of the intensity. It eliminates the need for raising the Geiger tube out of the equatorial plane and suggests that the reciprocal lattice be surveyed by either "zone" or "cone" schemes. These are described, and the "cone" scheme is shown to permit a complete hemisphere of the reciprocal lattice to be surveyed with only a single mounting of any crystal. Fine points concerning the use of the apparatus in the precise orientation of a crystal, and for the measurement of integrated intensities at single settings, are given. All angular motions are controlled by worm wheels and worms with dials for direct reading to 0·01°. Data collection is further facilitated by computing appropriate angular co-ordinates for reciprocal lattice points from an accurate set of lattice parameter measurements (readily obtained with the same instrument) and setting the various circles accordingly. The long spacings, characteristic of protein crystals, require both the high precision of this instrument and computed co-ordinates for the many thousands of reflections that must be measured. A.

548.733

6622. A high-temperature X-ray diffraction powder camera. E. Matuyama. *J. sci. Instrum.*, **32**, *No.* 6, 229–31 (*June*, 1955).

A high-temperature Debye–Scherrer camera fitted with a small carbon-tube furnace, which is capable of attaining temperatures as high as 1 800°C, is described. The furnace is housed in an evacuated cylinder having a slot covered with an aluminium foil. The scattered X-rays pass through the foil and impinge on a photographic film 20 cm in diameter. The camera records a comparison pattern on a film. The coefficients of thermal expansion of Ceylon graphite determined with the camera are $0{\cdot}95\times10^{-6}$ and $28{\cdot}09\times10^{-6}$ respectively for *a*- and *c*-dimensions in the temperature range 1 000–1 800°C. A.

548.734

6623. A method of correcting the broadening of X-ray line profiles. R. N. Bracewell. *Austral. J. Phys.*, **8**, *No.* 1, 61–7 (*March*, 1955).

A numerical method is presented which allows X-ray line profiles to be corrected for instrumental broadening. It provides an alternative to the use of Fourier analysis as described by Stokes. A special development of the method (as hitherto used) is necessary to permit its application to X-ray analysis where the $K\alpha$ doublet constitutes a complication. A.

548.735

6624. Method of correction for the $\alpha_1\alpha_2$ doublet in the X-ray diffraction lines. A. Papoulis. *Rev. sci. Instrum.*, **26**, *No.* 5, 423–6 (*May*, 1955).

In many applications it is necessary to determine the diffraction pattern due to monochromatic radiation. When the X-ray beam contains two frequencies α_1 and α_2, the experimental pattern $P(2\theta)$ equals the sum of the contributions $f(2\theta)$ and $kf(2\theta-\delta)$ of the α_1 and α_2 components. A graphical method of determining $f(2\theta)$ from $P(2\theta)$ is given, with the assumption that $f(2\theta)$ is symmetrical. The area $A(2\theta)$ under the $P(2\theta)$ curve is plotted, from which the position of the maximum and the shape of $f(2\theta)$ is easily determined. In this construction it is not necessary for $P(2\theta)$ to have a well-defined zero. A.

548.735.4 : 535.42

6625. Photographic preparation of masks of large molecules for the Lipson diffractometer. C. W. Hooper, W. E. Seeds and A. R. Stokes. Letter in *Nature* [*London*] **175**, 679–81 (*April* 16, 1955).

For diffractometer, see Abstr. 5209 (1953). An array of several unit cells of the structure is photographically reduced. The gelatine is etched out of the unexposed parts of the photograph, and the emulsion stripped off and laid on an optical flat. Optical-thickness differences are thus eliminated. Holes of any diameter down to 100 μ can easily be obtained. A. R. Stokes

548.735.46

6626. Patterson projections of symmetrical crystals. M. J. Buerger. *An. Real Soc. Espan. Fiz. Quim.*, **50(A)**, *No.* 11–12, 221–54 (*Nov.–Dec.*, 1954) In Spanish.

Simple Patterson maps can be analysed by resolving the diagrams into polygons. This is difficult if the crystal contains many atoms per unit cell, but if the crystal is also symmetrical, the interpretation of Patterson maps may be aided by considerations of symmetry. The theory of symmetrical Patterson maps is systematically discussed, and nine theorems concerning them are developed. These treat of the relation of vectors to symmetry operations, the relation of vectors corresponding to various symmetry operations to each other, fundamental peaks and satellites, the general law of satellites, the relation of peak weight to symmetry, the characteristic sheaf of vectors and its condensation, the relation of subsets of vectors to subgroups of operations, and the relation between unsymmetrical and symmetrical vectors. The application of this theory to several practical problems is discussed. In practical Patterson analysis it is important to place the map on an absolute basis, and the method of doing this is developed. A.

548.735.46

6627. A note on the Patterson functions. C. R. Putnam. *Quart. appl. Math.*, **13**, *No.* 1, 105–6 (*April*, 1955).

It is shown that a step function can be constructed, having only one maximum, such that its Patterson function has n maxima, where n may be any number. See also Abstr. 3923 (1951). A. R. Stokes

548.736.3

6628. The crystal structure of Mn_2Sb. L. HEATON AND N. S. GINGRICH. *Acta cryst.*, **8**, *Pt* 4, 207–10 (*April*, 1955).

The crystal structure of Mn_2Sb has been re-examined. Rotation and Laue patterns from small fragments and patterns using powdered samples confirmed the published tetragonal structure with $a = 4{\cdot}08$, $c = 6{\cdot}56$ Å. Large single crystals were grown to make possible a study of reflections from 00*l*, *h*00 and *hh*0 planes. Revised values of parameters are $z_{Mn} = 0{\cdot}295$ and $z_{Sb} = -0{\cdot}280$. From 100 to 500°K, the Debye characteristic temperature for reflections from the 00*l* planes is $3{\cdot}0 \times 10^2$ °K and for reflections from the *h*00 planes is $2{\cdot}8 \times 10^2$ °K. Above 500°K the intensities fall off more rapidly than expected. At room temperature the expansion coefficient along the *c*-axis is $1{\cdot}4 \times 10^{-5}$/°C and along the *a*-axis is $4{\cdot}0 \times 10^{-5}$/°C. A.

548.736.3

6629. The crystal structure of $RhSe_2$. S. GELLER AND B. B. CETLIN. *Acta cryst.*, **8**, *Pt* 5, 272–4 (*May*, 1955).

The crystal structure of RhSe has been determined from X-ray powder diffraction data. $RhSe_2$ has the pyrite-structure (*C*2 of the *Strukturbericht*). Four rhodium atoms are in positions 4(*a*): (0, 0, 0; $\frac{1}{2}, \frac{1}{2}$; ↙↗) and eight selenium atoms in positions 8(*c*): ± (x, x, x; $\frac{1}{2} + x, \frac{1}{2} - x, \bar{x}$; ↙↗) of space group T_h^6—*Pa*3, with $x = 0{\cdot}380 \pm 0{\cdot}002$. A homogeneity range exists for the structure between about 60 and 71·4 atomic % selenium with a decrease in lattice constant with increasing selenium content. A.

548.736.3

6630. The crystal structures of RhTe and $RhTe_2$. S. GELLER. *J. Amer. Chem. Soc.*, **77**, *No.* 9, 2641–4 (*May* 5, 1955).

The crystal structures of three rhodium tellurium phases have been determined from X-ray powder diffraction data. RhTe has the NiAs(B8) type structure. The high temperature form of $RhTe_2$ has the $Cd(OH)_2$(C6) type structure and the low temperature form has the pyrite (C2) type structure. The latter which has the lower volume per $RhTe_2$ is a superconductor at 1·51°K discovered by Matthias *et al.* [Abstr. 6629 (1954)]. A.

548.736.3

6631. X-ray analysis of compressed KCl powder crystals. J. G. KEREIAKES. Letter in *Phys. Rev.*, **98**, *No.* 2, 553–4 (*April* 15, 1955).

Diffraction photographs of samples produced at pressures up to 200 000 lb/in^2 are reproduced. Those produced at or above 20 000 lb/in^2 give patterns which are neither spotty nor broadened. A. R. STOKES

548.736.4

6632. Crystal structure of brucite $Mg(OH)_2$ and portlandite $Ca(OH)_2$ in relation to infrared absorption. H. E. PETCH AND H. D. MEGAW. Letter in *J. Opt. Soc. Amer.*, **44**, *No.* 9, 744–5 (*Sept.*, 1954).

Rotation and oscillation photographs were taken of crystals of brucite and portlandite in order to clarify previous contradictory evidence from X-ray and infrared investigations. The small unit cell and space group based on the X-ray results were confirmed. The portlandite crystals gave sharper photographs than those of brucite. Spectral data indicate a complicated spectrum for both crystals: for brucite this cannot be due to the poor quality of the crystals, which is indicated by the X-ray diagrams. Thus the brucite structure must involve an anomalous effect yet to be investigated. A. J. TAYLOR

548.736.4 : 539.132

6633. Crystal structure and quadrupole coupling of cyanogen bromide, BrCN. S. GELLER AND A. L. SCHAWLOW. *J. chem. Phys.*, **23**, *No.* 5, 779–83 (*May*, 1955).

The crystal structure of BrCN has been determined from single-crystal X-ray data. BrCN belongs to space group $D_{2h}(13)$—*Pnmm*, with two molecules in a unit cell of dimensions: $a = 5{\cdot}80$, $b = 6{\cdot}02$, $c = 4{\cdot}12$ Å (all ±0·03 Å). All atoms are in positions 2(*a*): ± (x, ¼, ¼) with parameters $x_{Br} = 0{\cdot}144$, $x_C = 0{\cdot}45$, and $x_N = 0{\cdot}65$. The structure is made up of straight chains of BrCN molecules directed along the *a*-axis with the bromine atom of one molecule bonding weakly to the nitrogen of the next molecule in the same chain. The structure is consistent with recent measurements of quadrupole coupling for the Br and N nuclei. A.

548.736.4 : 535.343

Structure of ammonia fluoride. *See Abstr.* 6002

548.737

6634. Crystal structure of benzene: a new type of systematic error in precision X-ray crystal analysis. E. G. COX, D. W. J. CRUICKSHANK AND J. A. S. SMITH. Letter in *Nature* [*London*] **175**, 766 (*April* 30, 1955).

Experimental values of the parameters of anisotropic thermal motion of the carbon atoms are given, and the effect of this thermal motion on the measured C–C distances is discussed. A. R. STOKES

GEOPHYSICS 55

550.372

6635. Electromagnetic induction within the earth and its relation to the electrical state of the earth's interior. I (1). T. RIKITAKE. *Bull. Earthquake Res. Inst.* [*Tokyo*] **28**, 45–100 (1950).

Taking as a basis the variations of the magnetic field observed at the surface, the primary exterior effects can be separated from the induced currents which they produce and information obtained on the earth's internal conductivity. The author adapts mathematical methods already used, notably by Price, to a large number of cases: the earth is considered as a sphere of uniform conductivity surrounded by two envelopes of lower conductivity; the variations considered are the mean diurnal variation, the diurnal variation for perturbed days, the variation during an average magnetic storm, the variation during a magnetic bay. MATHEMATICAL REVIEWS

550.372

6636. Electromagnetic induction within the earth and its relation to the electrical state of the earth's interior. I (2). T. RIKITAKE. *Bull. Earthquake Res. Inst.* [*Tokyo*] **28,** 219–62 (1950).

Continuing the work reported in the preceding abstract, the author considers magnetic crochets and sudden commencements. In the case of the first, he replaces the electromagnetic induction in a sphere by the induction under a plane; he estimates the resulting error. MATHEMATICAL REVIEWS

550.372

6637. Electromagnetic induction within the earth and its relation to the electrical state of the earth's interior. II. T. RIKITAKE. *Bull. Earthquake Res. Inst.* [*Tokyo*] **28,** 263–83 (1950).

Pt I suggested a model of the earth in which the conductivity is constant in a [surface] layer, under which it increases as the $-n$th power of the distance from the centre. The author reconsiders this model, again following Price's methods, but with numerous approximations. He finds n to be of the order of 10. MATHEMATICAL REVIEWS

550.38

6638. Theories of the earth's magnetism. D. R. INGLIS. *Rev. mod. Phys.*, **27,** *No.* 2, 212–48 (*April*, 1955).

The earth's core may be assumed to consist of fluid metal surrounding a solid inner core which probably contains a source of heat to drive convection, but it is not possible at present to select between various possible types of convective motion in the fluid core. Types considered are characterized by some sort of radial flow streams and a tendency for the fluid to rotate on the average more rapidly near the axis to conserve angular momentum during the circulation. Though the actual flow may be quite complicated, proposed mechanisms for generating a terrestrial magnetic field are considered for some oversimplified flow patterns in an attempt to indicate what features of the flow may provide the most important possibilities for field generation. It is suggested that, without a field to absorb the energy, the flow would be accelerated indefinitely and would evolve through a succession of flow patterns, some of which would be expected to have the properties to generate a field capable of preventing further acceleration and prolonging the *status quo*, thus making it likely that the earth should have a field. The generating mechanisms discussed include two induction theories, the dynamo theory of Elsasser and Bullard, which is discussed at length both in terms of velocity-current systems portrayed by elaborated models and in hydromagnetic terms, and the "twisted-kink" theory of Alvèn which is discussed only hydromagnetically. Each of these theories depends on amplifying an initial stray magnetic field up to a point where it dissipates all of the available energy, and is at least in this respect analogous to a conventional electrical generator but without a ferromagnetic core. Other mechanisms discussed depend either on the thermoelectric effect with junctions at the core-mantle interface or on a combination of thermoelectric and Hall effects in the core and mantle. If the convective flow is rather irregular, the observed slow westward drift of the detailed pattern of the earth's field is attributed to the vanishing of the total torque on the core by the magnetic field threading through the core and mantle, as a result of an eastward drag on the outer part of the core rotating more slowly in space and a westward drag on the more rapidly rotating part of the core near the axis, with the presumption that the observed magnetic pattern is characteristic of the westward-drifting outer part. If the flow instead involves a jet stream, the flow in the jet may under some circumstances be expected to be eastward for reasons comparable to temperate-zone meteorology, so the magnetic field should exert a westward drag on it leading to the westward drift of the flow pattern. A.

550.381

6639. Recent progress in the theory of the main geomagnetic field. S. K. RUNCORN. *Sci. Progress*, **43,** 13–27 (*Jan.*, 1955).

550.384 : 550.387

6640. Sudden impulses in telluric currents and their relation to the sudden impulses of the terrestrial magnetic field. L. DE MIGUEL Y GONZALEZ MIRANDA. *Rev. Geofis.*, **13,** 155–66 (*April–June*, 1954) In Spanish.

It has been observed that in the earth-current records there is a far greater sensitiveness than in the magnetic ones when recording certain kinds of disturbances, such as the polar ones. These may even be unnoticed in a magnetic record, when they are of vibratory kind, but they can be easily observed on an earth-current record. Earth current equipment in all the magnetic observatories would therefore be useful in the study of these disturbances. A.

550.385

6641. Notes on the theory of magnetic storms. S. CHAPMAN. *Indian J. Meteorol. Geophys.*, **5,** *Special No.*, 33–40 (*Dec.*, 1954).

A non-mathematical account is given of the model problems and their solutions, by which Chapman and Ferraro have sought to illustrate some aspects of the theory of magnetic storms. These problems are here used to develop a qualitative solution of the motion of an infinite neutral ionized plane sheet of gas (or of a succession of such sheets) towards a unidirectional magnetic field whose intensity decreases as an inverse power of the distance from an axis to which the sheet is parallel. The gas in the centre approaches to a minimum distance from the axis and then recedes again. The gas far to either side moves onward with little distortion. Between these central and outer parts there are two strips of the sheet whose ions and electrons separate from each other, under the influence of the magnetic field; partly because these strips become much extended and reduced to low density. Some charges are deviated away to infinity, others are captured by the field and build up a "westward" electric current to which is ascribed the main phase of a magnetic storm. A.

550.385 : 551.510.535 : 523.745

6642. Effect of solar activity on ionosphere and earth's magnetic field. S. N. MITRA AND S. C. MAZUMDAR. *Indian J. Phys.*, **28,** *No.* 12, 563–80 (*Dec.*, 1954).

Analyses radio fade-outs and magnetic storms with a view to correlating them with solar flares and sunspot numbers. Data for the years 1946–49 have

been analysed. Dellinger fade-outs have been observed to be well correlated with solar flares. Based on the theory of corpuscular emission from solar disturbances, delayed types of fade-outs and magnetic storms have been observed to go together and the delay time gives an approximate measure of the speed of the corpuscles. Occurrence of a solar flare has also been found to agree with that of high sunspot number. The analysis of the magnetic character figure indicates that it has no regular relationship with sunspot numbers. However, the central meridian passage of large sunspot groups is often found to be associated with flares, fade-outs and magnetic storms. Various correlations have been represented in the form of graphs and tables. A very high percentage of radio fade-outs has been found uncorrelated with solar flares and sunspot numbers. It has been postulated that such radio fade-outs may be caused by *M*-region activity. A.

ATMOSPHERE . METEOROLOGY 551.5

551.508.1

6643. Instrumentation of the rocket-grenade experiment for measuring atmospheric temperatures and winds. W. G. STROUD, E. A. TERHUNE, J. H. VENNER, J. R. WALSH AND S. WEILAND. *Rev. sci. Instrum.*, **26**, *No.* 5, 427–32 (*May*, 1955).

The temperatures and winds in the upper atmosphere have been measured by means of the Aerobee sounding rocket. The determination of the velocity of sound between grenades ejected from the rocket and exploded at successive heights measures the temperatures. The angles of arrival of the sound waves at the ground are used to determine the winds. The experimental method is outlined and the rocket-borne and ground instrumentations are described. A summary of the rocket firings carried out is also given. A.

551.510.535

Radio-wave propagation in the ionosphere. *See also under* "Electromagnetic waves and oscillations." Decimal classification 538.566.3

551.510.535

6644. Measurement of the ionospheric wind from the speed of motion of a state (e.g. echo field strength) along the surface of the earth. P. S. PÜTTER. *Physics of the ionosphere* [*Cambridge*] 191–201. See Abstr. 5763 (1955) In German.

The aim of the pulse-echo-method is to measure the speed of an amplitude pattern over the ground. For that purpose the fading records from at least three aerials are used and the speed of a portion of a line of maximum (or minimum) intensity is measured. It is, however, only the movement of such a line in a direction perpendicular to itself which can be detected; this may be called the speed of the line element. It is, then, only possible to identify this speed with that of the whole amplitude-pattern if the pattern moves in a direction perpendicular to the line element. This is not usually the case, and a new method of analysis must be looked for. It is then found that the speed of the amplitude pattern cannot be deduced from one measurement of the speed of a line-element. The comparison of different possibilities shows that the "method of time-vectors" is especially suitable. It is shown that the measured time differences may be regarded as the components of a vector which is called the "time-vector." If for a constant velocity of the amplitude-pattern all the measured time-vectors are drawn from one point, then their end points will be situated on a straight line. A simple calculation shows that the normal to this straight line gives the required speed of the amplitude-pattern. A.

551.510.535

6645. Researches on the interaction and self-demodulation of electromagnetic waves. E. CARLEVARO. *Ricerca sci.*, **25**, *No.* 3, 521–31 (*March*, 1955) In Italian.

Review of Italian ionospheric research. Some experiments in Britain, U.S.A., Australia, India and Russia are included; also Italian work on general weather conditions and the effect of sunspots on radiocommunication. Activities of the Ionospheric Congress of March, 1952 are reported. A full bibliography of relevant Italian publications since 1950 is given. J. J. PHIPPS

551.510.535 : 523.745 : 550.385

Effect of solar activity on ionosphere and earth's magnetic field. *See Abstr.* 6642

551.510.535 : 538.566.3

Ionospheric self-interaction of radio waves. *See Abstr.* 6323

551.510.535 : 551.594 : 621.396.11

6646. Irregularities in the *E* region caused by atmospheric electricity. G. A. ISTED. *Physics of the ionosphere* [*Cambridge*] 150–62. See Abstr. 5763 (1955).

Single-hop communication over distances up to 1 500 km, on radio frequencies between 30 and 60 Mc/s, is practicable when use is made of the irregularities existing in the *E*-region. Many of these irregularities give rise to sporadic echoes of short duration which may be detected at vertical incidence when the *E*-region is illuminated by radio frequencies of 5–100 Mc/s. Some of these echoes are undoubtedly due to ionization caused by meteors, but experimental evidence suggests that the majority observed on the lower frequencies are due to weather clouds discharging upwards to the *E*-region where ionization is produced above the cloud. These upwardly directed weather cloud discharges do not necessarily involve lightning between ground and cloud but the change in the electric field may be detected at great distances in the form of an "atmospheric." This type of atmospheric can be distinguished from the type caused by lightning, and radio directional measurements show that the greatest concentrations of both types emanate from the great equatorial land masses illuminated in turn by the sun. Because these world-wide upward cloud discharges maintain the *E*-region at a high potential, the vertical field of which is found in areas of clear sky, they exercise a rigid control over the ability of a local cloud to discharge, and a close relationship therefore exists between the diurnal variation in the number of world-wide discharges and the number of *E*-region sporadic echoes. A.

551.578.11

6647. The coalescence between small water drops. J. W. TELFORD, N. S. THORNDIKE AND E. G. BOWEN. *Quart. J. Roy. Meteorol. Soc.*, **81**, 241–50 (*April*, 1955).

An experiment is described for measurement of the rate of coalescence in a cloud of droplets of nearly equal size. It is found that the value of the collection efficiency is unexpectedly high, and a physical explanation of the effect is given. The influence of electric charges on the droplets has been observed, and it is shown that increases by a factor of up to 20 in the collection efficiency are possible. A.

551.578.41

6648. Radar evidence for aggregation and orientation of melting snowflakes. B. J. MASON. *Quart. J. Roy. Meteorol. Soc.*, **81**, 262–4 (*April*, 1955).

Measured values of the relative intensities of the echoes received from the melting zone, the snow above and the rain beneath suggest that, in general, each snowflake in the melting zone coagulates with one or more (on average, two) others of much the same mass to form horizontally-oriented aggregates which scatter as oblate water spheroids of mean diameter/axis ratio 4. A.

551.593.9

6649. Infra-red radiation of the night sky. V. I. KRASOVSKIĬ. *Uspekhi fiz. Nauk*, **54**, *No.* 3, 469–94 (1954) In Russian.

This is a critical survey by the leading Soviet worker in the field. The source of much i.r. radiation from the night sky is the hydrogen in the upper atmosphere. Hydrogen in interstellar space and in the upper atmosphere is also the subject of much work in radioastronomy so that now two different approaches are possible upon a problem of high interest in cosmogony. Most of the ionization of the *D*-layer at 50–100 km height is attributed to absorption of the L_α line (1 217 Å) due to hydrogen in the sun. The author discusses reactions giving rise to excited OH and O_2. Difficulties arising from lack of precise values for the constants of elementary chemical processes and the de-activation of excited states hinder the satisfactory interpretation of the i.r. radiation from the upper atmosphere. The author puts forward a simplified picture of de-activation. An addendum deals with the problem of selective excitation of the zero vibrational level of the $^1\Sigma$ state of oxygen molecules and its consequences. The opposing views of Meinel are discussed, also their application to the explanation of Végard and Kaplan–Herzberg bands which suggest that excited O_2 molecules arise at lower levels than the above where the concentration of atoms of H, N or O is insignificant. In such circumstances O_2 molecules in the $^1\Sigma$ state with high vibrational excitation may effectively lose this excitation in collision with oxygen and nitrogen. The indications of a relatively low height at which the $O_2(^1\Sigma - {}^3\Sigma)$ band arises are added reasons for the suggestion that the radiation results from the oxygen–hydrogen reaction. 70 refs to the literature, nearly all post-1951. C. R. S. MANDERS

551.593.9

6650. Search for discontinuities in the brightness of the twilight sky. R. V. KARANDIKAR. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 389–92 (*May*, 1955).

Grandmontagne and later Vaucouleurs have observed discontinuities in the slope of the zenith-sky brightness curve during twilight at solar depressions of about 6, 9, 10, and 12°, which are explained to be due to separate diffusing and luminescent layers in the upper atmosphere. No such evidence is, however, found by Koomen and co-workers in their recent photoelectric measurements in the United States. The effect of a possible discontinuity could be enhanced by observing the difference in radiance of two similar patches of the zenith sky in the sun's meridian, this being more susceptible to changes accompanying the crossing of a layer by the earth's shadow. Observations on very clear days with a photoelectric differential twilight photometer recording this difference through three narrow-band interference filters have not disclosed any evidence of the discontinuities, the recorded curves running perfectly smooth till the end of astronomical twilight. From estimates of the least radiant energy which the photometer could detect, the possibility of detecting a layer of scattering material at the heights of the reported discontinuities is discussed. A.

551.593.9 : 535.333

6651. Seasonal variations of intensity of the molecular bands of atmospheric OH and O_2 in the night-sky luminescence. P. BERTHIER. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 18, 1796–8 (*May* 2, 1955) In French.

Spectrophotometry of near i.r. spectra of the night-glow reveals characteristic differences in the seasonal intensity-variation of the OH and O_2 bands. For OH there appears a single maximum in winter, with a minimum in summer; resembling the seasonal fluctuation for atmospheric Na emission. By contrast, the much less regular seasonal curve for O_2 exhibits four maxima, suggesting a connection with the co-variant Herzberg O_2 bands and the O I green line. D. R. BARBER

551.593.9 : 535.333

6652. Infrared emission spectrum of the atmosphere. R. SLOAN, J. H. SHAW AND D. WILLIAMS. *J. Opt. Soc. Amer.*, **45**, *No.* 6, 455–60 (*June*, 1955).

A device for the convenient quantitative measurement of the thermal radiation from the atmosphere has been developed. In the instrument the emission spectrum of the earth's atmosphere as observed at ground level is compared automatically with a spectrum approximating that of a blackbody at the boiling point of liquid nitrogen at atmospheric pressure. The most prominent features of the atmospheric spectrum between 4μ and $15{\cdot}5\mu$, observed during daylight and darkness when the sky is clear, are due to emission by carbon dioxide, ozone and water vapour; the intensity of the water vapour emission shows pronounced variations with atmospheric temperature and humidity. The spectrum of an overcast sky resembles that of a blackbody. By comparing the recorder traces of the atmospheric spectra with similar traces obtained with a blackbody source, it is possible to estimate the effective radiation temperature of various portions of the sky for various atmospheric conditions. A.

551.593.9 : 537.591

6653. Light-pulses from the night sky and Čerenkov radiation. I. W. GALBRAITH AND J. V. JELLEY. *J. atmos. terrest. Phys.*, **6**, *No.* 5, 250–62 (*May*, 1955).

See Abstr. 8132 (1953). Further investigations have been made of the phenomenon of the light associated with cosmic-ray air-showers. The polarization and directional properties of the light have been investigated and an experiment has been done to study its colour. The results are consistent with at least some of the light being Cherenkov radiation. A.

551.593.9 : 551.594.5

6654. The frequency distribution of the intensity of aurorae and the night airglow for 5577 [O I]. P. ST. AMAND AND E. V. ASHBURN. Letter in *J. geophys. Res.*, **60**, *No.* 1, 112–13 (*March*, 1955).

Discusses whether such distributions will assist in deciding whether these are two phenomena or different manifestations of the same phenomenon. The data available are not adequate and it is suggested that continuous records at a station in the auroral zone would answer the question. J. M. HOUGH

551.594.13

6655. Conductivity measurements in the stratosphere. C. G. STERGIS, S. C. CORONITI, A. NAZAREK, D. E. KOTAS, D. W. SEYMOUR AND J. V. WERME. *J. atmos. terrest. Phys.*, **6**, *No.* 5, 233–42 (*May*, 1955).

The electrical conductivity of the atmosphere from gound up to 100 000 ft was measured during a series of five balloon flights made in 1953. The tests indicate that the conductivity of the atmosphere increases monotonically up to the maximum height at which measurements were made. The variation of conductivity with altitude follows closely the variation expected from cosmic-ray intensity data. On none of the flights was there a clear indication that the conductivity diminishes in the region of 65 000 ft above sea level as obtained during the Explorer II flight in 1935. It is concluded that the phenomenon observed on Explorer II is not a universal one. A.

551.594.14

6656. Fresh outbreak of activity of atomic origin in the atmosphere. H. GARRIGUE. *C.R. Acad. Sci. [Paris]* **240**, *No.* 13, 1453–5 (*March* 28, 1955) In French.

During the period Dec. 1954 to Feb. 1955 values of the order of 1 β-emitting atom per cm^3 of air have been obtained for observations on the ground and in the air in the Puy de Dome region. J. M. HOUGH

551.594.14

6657. Beryllium-7 produced by cosmic rays. J. R. ARNOLD AND H. A. AL-SALIH. *Science*, **121**, 451–3 (*April* 1, 1955).

It was expected that star production in nitrogen and oxygen would produce Be^7 and that this would eventually reach the earth in rain water. A series of samples of rain water from Chicago and Lafayette were treated to concentrate the activity and various tests showed that this was due to Be^7; further, no change in level was detected after nuclear weapon tests and so the source was cosmic-rays. At Chicago 6×10^5 atoms per cm^2 are received in a year at the earth's surface. It appears possible to use this isotope to obtain data on processes of air movement in the troposphere and lower stratosphere. J. M. HOUGH

551.594.221

6658. Electrostatic field-changes due to lightning discharges. E. T. PIERCE. *Quart. J. Roy. Meteorol. Soc.*, **81**, 211–28 (*April*, 1955).

Extensive observations are described of the changes of electrical field produced by lightning discharges at distances of less than 100 km; in this range electrostatic effects are dominant. The results are analysed in detail. A long series of capillary-electrometer records obtained with auxiliary amplifying equipment give statistical information upon the magnitude–distance and sign–distance relationships for the total electrostatic field-change due to a lightning flash. From oscillographic observations it is shown that most of this change in field occurs comparatively slowly. It has proved possible to separate field-changes into distinct groups; these are considered in turn and values given for such quantities as the electric moment and the times involved in each stage, etc. Finally, meteorological influences and the relative frequency of occurrence of cloud and ground discharges are investigated. A.

551.594.221

6659. The development of lightning discharges. E. T. PIERCE. *Quart. J. Roy. Meteorol. Soc.*, **81**, 229–40 (*April*, 1955).

The interpretation of experimental observations, described in the preceding paper, of the electrostatic field-changes due to lightning flashes, is considered. It is found that almost all the recorded field-changes can be most simply explained in terms of leaders carrying negative charge and originating in the lower part of a thundercloud. Those that reach the ground are succeeded by return strokes. It is considered that both leaders and return strokes consist of a central core surrounded by an envelope of corona; this corona concept, originally advanced by Bruce, leads to a coherent picture of the phenomena observed. A.

551.594.25

6660. The electric charge of raindrops. L. G. SMITH. *Quart. J. Roy. Meteorol. Soc.*, **81**, 23–47 (*Jan.*, 1955).

The observations were obtained using equipment designed to record rapidly, and without ambiguity, the electric charge and size of individual raindrops. The electric charge is measured by electrostatic induction on a metal cylinder as the drop falls through. The size of the smaller drops is determined from the time of fall between two such cylinders, while the size of the larger drops is measured by the change of capacity of a parallel-plate condenser as the drop passes between the plates. The point-discharge current, electric-field strength and rain current were also measured. The observations show that on all occasions the range of charge on a particular size of drop is large, often including both signs, and that this range is not appreciably reduced by considering drops recorded during shorter time intervals. However, it is often found that the average charge and the limits of the range of charge show definite relations to the size of the drop. The variation of average charge is such that there is a certain size for which the average charge is zero; for smaller drops the average charge is opposite in sign to that of the electric field, while the larger drops have average

charges of the same sign as that of the electric field. On some occasions the charges on the drops are too small to be recorded. The field is then usually reversed to a small negative value. It is suggested that the drops are falling from electrically neutral or slightly electrified clouds, the reversal of the field resulting from the splashing of drops on the ground. The capture of ions by raindrops falling in the region of the point-discharge current below an electrified cloud is examined and it is shown that, if reasonable assumptions are made about the initial charges on the drops, the relation between the charge and size of drops arriving at the ground is similar to that found experimentally. Comparison of theory and experiment indicates that the field increased with height owing to the point-discharge space charge. The range of charge is attributed to the mixing, while falling, of drops leaving the cloud base in regions of different current density. This requires that the regions of high current density are small areas of the cloud base, probably not exceeding 100 m in diameter. A.

BIOLOGY 57/59

578.087.8 : 621.375.2.029.4

6661. Amplifier for 5734-tube bristle flowmeter. J. Praglin and G. A. Brecher. *Rev. sci. Instrum.*, **26**, *No.* 4, 385–7 (*April*, 1955).

An amplifier and power supply for a stable, high frequency, electronic, bristle flowmeter is described. The transducer element is the RCA 5734 tube. The difficulty in applying this tube to blood flow measurements is overcome by use of a 500 000 ohm load resistor instead of the 75 000 ohm value recommended by the manufacturer. The advantages of this device are commercial availability of flow-sensing element, high signal-to-noise ratio, good maintenance of the zero flow base line, response to backflow as well as forward flow, and provision for the recording of either phasic or mean flow. A.

578.6

6662. A computing microphotometer for cell analyses. S. Bourghardt, H. Hydén and B. Nyquist. *J. sci. Instrum.*, **32**, *No.* 5, 186–9 (*May*, 1955).

A scanning and printing computing microphotometer for analyses of large quantities of tissue cells and cell structures is described. One pertinent problem in quantitative cytology using microspectrography within some range of the spectrum, is the time it takes to obtain quantitative data on specific substances from many measurements on each cell and then to repeat them on many cells in order to get statistically significant results. Every problem on differentiation, cell growth or function involves this difficulty, when the specimen is a section through a number of cells. With the apparatus 12 000 measurements can be made on an area 30×36 mm and the results are automatically computed and recorded in numbers point by point as they occur in the specimen. The area of the specimen covered by a single measurement is usually $3\mu^2$, and an ultimate resolution of 1μ is possible. Due to a special control system every detail within the microscopic image can be localized and measured separately. A.

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.821 : 519.2

6663. New method for the assignment of psychometric scale values from incomplete paired comparisons. J. H. Morrissey. *J. Opt. Soc. Amer.*, **45**, *No.* 5, 373–8 (*May*, 1955).

The principle of least squares is applied to the selection of an optimum set of n response values, or of $(n-1)$ basic response differences, corresponding to n stimuli, from m observed response differences provided by the paired-comparison method of psychometric measurement. This method of selection is shown to be the most appropriate generalization, to the case of a usable but incomplete set, i.e. with $n-1 \leqslant m < \frac{1}{2}n(n-1)$, of observed response differences, of a corrected form of the algorithm of J. P. Guilford. Unlike the Guilford algorithm, however, direct application of the least-squares principle implies response values which are independent of the *a priori* ordering of the n stimuli, even in the incomplete-set case. A.

612.843.31 : 621.397

6664. The physiology of colour television. Y. Le Grand. Letter in *Optica Acta*, **1**, *No.* 4, 190–1 (*Feb.*, 1955) In French.

A calculation is made of the XYZ co-ordinates of primaries suitable for colour television. Since the green primary is $10\times$ as large as the blue when white (6 740°K) is to be matched, and visual acuity is related to the log luminance by a slope of 0·5, only half the "acuity requirements" of black and white television need be met in colour television. The factor of 0·5 is probably a minimum. R. A. Weale

612.843.31 : 621.397.3

6665. The behaviour of the eye and the rational transmission of simultaneous images. I. G. A. Boutry, P. Billard and L. Le Blan. *Onde élect.*, **34**, 824–37 (*Nov.*, 1954) In French.

Describes a large number of experiments designed to determine the limits of perception of the eye in respect of (*a*) pollution of a tint by a change in the luminance or chromaticity co-ordinates of one of the primaries composing it, (*b*) angular resolution of luminance or chromaticity changes and (*c*) flicker. The primaries used in the experiments differed slightly from those recommended by earlier workers, being green, with chromaticity co-ordinates $x = 0{\cdot}217$, $y = 0{\cdot}644$, red ($x = 0{\cdot}676$, $y = 0{\cdot}324$) and blue ($x = 0{\cdot}142$, $y = 0{\cdot}061$), the choice being governed by availability of luminescent materials for the screens of c.r.t.'s. W. G. Stripp

612.843.45

6666. Haidinger's brushes and circularly polarized light. W. A. Shurcliff. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 5, 399 (*May*, 1955).

A number of experiments on this phenomenon are described. The observer's two eyes saw the brush uni-ocularly at approximately equal angles—a sur-

prising "lack of bilateral symmetry in the pair of eyes." R. A. WEALE

612.843.6 : 537.531

6667. The relation of physiological optics to, and the objects of technical optics in, the introduction of image-converters in the intensification of X-ray images. H. JENSEN. *Optik*, **12**, *No.* 3, 105–16 (1955) In German.

Data given by Blackwell [Abstr. 1089 (1947)] and Brown *et al.* [Abstr. 4531 (1953)] are applied to visual problems of X-ray image-convertors. A description is given of an arrangement embodying an image-convertor with visual and photographic registration. R. A. WEALE

612.843.721

6668. On the influence of the size, eccentricity, and spectral composition of a test field on nocturnal binocular convergence. C. BOURDY. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 13, 1475–6 (*March* 28, 1955) In French.

This visual function C was studied for luminance levels betwen 1 and 10^{-6} nits. Field size varied from 14° 2′ to 35′, eccentricity from 4° 18′ to 31° 48′. For large test-fields C was constant, but diminished with decreasing size for small ones. Increased eccentricity reduced C, which also revealed the operation of the Purkinje effect. R. A. WEALE

614.898

6669. A radon-in-air monitor for use in mines. L. W. D. PITTENDRIGH. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. HP/M83*, 5 *pp.* (1954).

The monitor described was developed to provide a means of giving almost instantaneous detection of radon in air during mining operations below ground. It is battery operated and entirely self-contained. A volume of one litre of air is continuously monitored by an arrangement of twin phosphors and photo-multipliers. Counting rates of 4 and 40 counts per second are provided, and with an overall efficiency of 50%, this gives ranges of 2×10^{-10} curie/litre and 2×10^{-9} curie/litre. Audible indication is either by loudspeaker or by headphones. A.

TECHNIQUE. MATERIALS 62/69

66/67 : 536.48 : 536.21

The thermal conductivity of some technical materials at low temperatures. *See Abstr.* 6076

PHOTOGRAPHY 77

778.33

6670. The effect of kilovoltage and grid ratio on subject contrast in radiography. H. E. SEEMANN AND H. R. SPLETTSTOSSER. *Radiology*, **64**, *No.* 4, 572–80 (*April*, 1955).

"Subject contrast" is defined as the ratio of X-ray intensities between the parts of the X-ray image under consideration; it is essentially independent of the method of measurement. The effect of scattered radiation on the value of the subject contrast is illustrated. In a series of experiments with water phantoms, subject contrast was found to vary with kilovoltage and grid ratio, decreasing with increasing kilovoltage and increasing with grid ratio. It is shown from the curves obtained that many conditions exist in which scatter removal more than offsets the decrease of contrast with increased kilovoltage. With increasing kilovoltage, subject contrast of bone substance decreases more rapidly than does subject contrast of tissue-like substance. Further experimentation will be required to determine whether image definition (as distinct from contrast) is adversely affected by the use of the higher kilovoltages. A.

778.33 : 535.826

6671. The use of the milling machine for preparing bone sections for microradiography and microautoradiography. J. JOWSEY. *J. sci. Instrum.*, **32**, *No.* 5, 159–63 (*May*, 1955).

Undecalcified bone can be embedded in Perspex in an oven which is designed to hasten the polymerization of the Perspex monomer so that short-lived isotopes may be studied. The sections are cut on an engineer's milling machine to 100μ and ground to approximately 50μ on ground glass. The sections are then X-rayed and autoradiographed so that the degree of calcification and the uptake of different isotopes may be correlated, the autoradiographic film being left on the sections so that the exact localization of the isotope may be determined. Both large-grained X-ray film and fine-grained autoradiographic film are used, depending on the concentration of isotope in the bone. This method can be used for hard adult cortical bone with satisfactory results. A.

778.34

6672. Measurements in nuclear emulsions. A. BONETTI, C. DILWORTH, M. LADU AND G. OCCHIALINI. *R.C. Accad. Naz. Lincei*, **17**, *No.* 6, 311–14 (*Dec.*, 1954) In Italian.

Describes a method for studying the "profile" of tracks of singly charged particles near the end of their range, by measuring the widths of the track at small intervals along the track. The information obtained in this way (lengths of blobs, widths of tracks and density of δ-rays) can be used to improve the accuracy of determinations of mass and charge of particles whose ionization is greater than three times minimum. P. ROTHWELL

778.34

6673. Study of the preparation of emulsions for ionizing radiation. J. KUBAL. *Czech. J. Phys.*, **5**, *No.* 1, 49–56 (*Feb.*, 1955) In German.

The conditions determining sensitivity are discussed, especially the AgBr/gelatine ratio. Three types of gelatine were used with different response to the ripening process, and recipes for emulsions are given. For each gelatine there were (1) a control emulsion; (2) one sensitized with 1-phenyl 2-methyl 3·5-bis [2(p-methylaminophenyl) vinyl] pyrazolium iodide; and (3) one containing aminophthalic hydrazide. The new sensitizer used in (3) was very effective, and about as good as that used in (2) for both light and α-particle exposure. S. T. HENDERSON

778.34 : 530.145

The multiple scattering from tracks with consideration of statistical coupling. *See Abstr.* 5895

778.34 : 539.18

Methods of determining the masses of charged particles detected in nuclear emulsions. *See Abstr.* 6505, 6507–10